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ORIGINAL ARTICLES.

I.—On *Labechia rotunda*, a new species of Stromatoporoid, from the Wenlock Limestone of Shropshire.

By Miss M. S. Johnston.

(PLATE XV.)

WHILST working at the fossils connected with our paper "A Study of Ballstone and the Associated Beds in the Wenlock Limestone of Shropshire",[1] my colleague, Miss M. C. Crosfield, and I became much interested in a small round form of *Labechia*. We did not find many specimens, about a dozen in all, although we spent a considerable time in collecting, and these were obtained at only three quarries, which contain otherwise a prolific fauna, viz. Bradley Rock and Shadwell Rock, Much Wenlock, and at Knole Quarry, Presthope. The tops of these quarries are in the highest beds of the Wenlock Limestone series and are of bands of irregularly shaped nodules of various sizes, with shale partings and of a light-brown colour (this latter fact distinguishes the beds from the rest of the limestone). It is only in these upper beds that this *Labechia* is found, but *Labechia conferta*, Lonsd., is found, often in great numbers and size, everywhere throughout the limestone, though perhaps slightly diminishing in quantity at the top. So far, I have not been able satisfactorily to identify this species. Nicholson, in his monograph,[2] mentions and figures a young example of *L. conferta*, which he records as only being 2 to 3 cm. in diameter and 1 mm. in thickness. This specimen agrees with mine, but I cannot believe that they are young *Labechia conferta*, Lonsd., for several reasons—

1. The species is only found in the highest beds, never in the lower.

2. The largest I have is 5½ cm. in diameter (Pl. XV, A, Fig. 1).

3. It is always thin, about 2 mm. thick (Pl. XV, A, Fig. 3, and B), and never has one colony superimposed on another (Pl. XV, A, Fig. 6; a *Labechia conferta* is 1 cm. thick).

4. The basal epitheca is nearly flat, not protuberant as is the case in many *L. conferta* (Pl. XV, Figs. 4, 5).

5. The rings of growth are always circular and never irregular (Pl. XV, A, Figs. 1, 2, and B).

The upper surface is seldom found exposed, but where it is seen it is irregularly or sometimes radially studded with minute tubercles.

[1] Proc. Geol. Assoc., vol. xxv, pt. iii, pp. 193-224, pls. xxxiii-vi, 1914.

[2] *British Stromatoporoids* (Pal. Soc.), p. 161, pl. iii, figs. 9-11.

They are not so high, but otherwise of the same size and shape, as the tubercles on *L. conferta*, and they also coalesce together. In the few specimens I have been able to examine, I have not found any summit-apertures on the tubercles. The rings of the base are ½ mm. wide. The radial pillars of the cœnosteum, which have a diameter of ¼ mm., traverse each ring, in the direction of its width, before turning to the upper surface, and give the appearance of regular radial ridging.

It seems to be of rare occurrence, as through the kindness of Mr. H. Woods and Mr. H. A. Allen I have been able to ascertain that there were none in the Sedgwick Museum, Cambridge, nor in the Museum of Practical Geology, Jermyn Street. (I have been able to supply the latter.)

I am also much indebted to Mr. W. D. Lang, at the British Museum (Natural History), South Kensington, for the help he has given me. The specimen, figured by Nicholson, is at this Museum, but the place of origin stated, the Wren's Nest, Dudley, is doubtful. It is much more likely that it came from the Much Wenlock district, as also did the other small specimen in the Museum. For these reasons I would make this a new species with the name *Labechia rotunda*, taking as the type the specimen figured on Plate XV, B, which was found at Shadwell Rock, Much Wenlock, Shropshire, and which I have deposited in the Geological Department of the British Museum (Nat. Hist.).

II.—The Ice Age in England.

By Dr. Nils Olof Holst (late of the Geological Survey of Sweden).

(*Continued from the September Number, p. 424.*)

AFTER the little survey of the pluvial epoch contained in the preceding section we may turn our attention again to England.

In the Thames Valley at Swanscombe (Barnfield pit) there is found beneath the deposits which yield early Chellean implements [1] a yet older layer which does not contain any implements.

Still somewhat younger, according to A. S. Kennard, is the so-called *Neritina* locality at Swanscombe. This, no less than the other, is of undoubted pre-Glacial age. Starting from this we may—thanks to the researches of the British palæontologists, and perhaps especially malacologists—construct a little series of other similar pre-Glacial occurrences in the following order from older to younger, all from the lower part of the Thames Valley.

1. *Swanscombe, Neritina locality.*—Characteristic molluscs: *Neritina grateloupiana*, *Valvata piscinalis*, var. *naticina*,[2] and *Vivipara* [*Paludina*] *diluviana*, which are all wanting in the following younger localities.

2. *Grays.*—*Valvata piscinalis*, var. *antiqua*. This is wanting in the following.

[1] *Elephas primigenius*, which is quoted as occurring in Barnfield pit, is really *E. antiquus*, the elephant characteristic of Chellean deposits.

[2] The statement that this mollusc is also found at Crayford depends upon an erroneous determination.

3. *Ilford.—Eulota* [*Helix*] *fruticum* and *Paludestrina* [*Hydrobia*] *marginata*, which latter is also found in 1 and 2. Both are wanting in the following.

4. *Erith–Crayford.— Corbicula fluminalis*, which is found also in 2 and 3, together with *Pisidium astartoides*, which is also found in 1, 2, and 3. Both are unknown from younger layers.[1]

These four pre-glacial occurrences are particularly interesting, since they show how one warmth-loving mollusc after the other disappears from the Thames Valley in proportion as the inland ice approaches; and the most warmth-loving as a rule disappears first. One of the earliest is *Vivipara* [*Paludina*] *diluviana*, which thus proves itself to be a distinctly pre-glacial shell, and even if found in a slightly later bed would still be pre-glacial. F. Wahnschaffe, therefore, as already remarked (p. 420), was completely right when, in 1893, he regarded this mollusc in the same way and called the *Paludina*-bed of Berlin pre-Glacial.

Of the four occurrences mentioned above, that of Erith–Crayford is the most interesting. It is the last in order and therefore that which came nearest to the Ice Age. None the less, it is certainly pre-glacial in this sense, that in England no earlier glacial epoch has ever been demonstrated or, we may be sure, ever will be demonstrated.

The molluscan fauna of Erith–Crayford, taken as a whole, is persistently temperate and pre-glacial, as is sufficiently proved by the presence of *Corbicula fluminalis*. *Planorbis arcticus*, however, has already come in, and *Pupa muscorum* has already become numerous.

At the same time, the more mobile mammals show more clearly than the two molluscs last mentioned that the inland ice is approaching. In the Crayford Bed are found *Ovibos moschatus*, *Lemmus* (two species), *Spermophilus* (here for the first time in England), *Microtus* [*Arvicola*] *ratticeps*, *Rhinoceros tichorhinus*, and *Elephas primigenius*, which is abundant, while *E. antiquus* has now become rare. *Hippopotamus*, which is already rare at Ilford and there perhaps only derived, has now wandered southward for good. It is the approaching inland ice which drives the northern animal before it.

Thus the mammalian fauna of Erith–Crayford shows precisely the same stage as the Campinian at Hofstade in Belgium. And I propose that this interesting and important stage should receive the name Campinian also in England.

The molluscan fauna, however, taken by itself, apart from the mammalian fauna, is quite enough to give the deposit of Erith–Crayford its true place, as appears from the following. My list of Mollusca from the Campinian of Hofstade is in large part new and not yet published, but when I showed this list to Mr. Kennard and asked him as to its English equivalent, he replied without the least hesitation, "That's Crayford."

Besides the molluscan and mammalian faunas, the Palæolithic finds also contribute to determine with certainty the correct period of Erith–Crayford. In the lower part of the Crayford Bed Mr. Brice Higgins—and others before him—has recently found Mousterian

[1] A. S. Kennard & B. B. Woodward, 1905. "The Extinct Postpliocene Non-marine Mollusca of the South of England": S.E. Nat., 1905, pp. 14–24.

implements.[1] Some of them can be completely matched among V. Commont's pre-Glacial implements from Moutières-les-Amiens,[2] as well as among M. de Puydt's contemporaneous implements from Sainte-Walburge.[3] In other words, it follows from this that the Palæolithic implements at Crayford belong to the oldest Mousterian, which has a stratigraphical position immediately below the deposits of the Ice Age, while the remaining portions of the Mousterian belong to the "maximum of glaciation".

Among the fossiliferous deposits at present known in the London district, the Arctic bed at Ponders End[4] belongs to the period immediately following the bed at Erith–Crayford. This both underlies and overlies gravel, and the whole is covered by loam. Since this last formation is the true 'late-glacial'[5] deposit, the Arctic bed cannot also be that. Neither can it be glacial. In that case it would have been deposited during some milder stage constituting a break in the Ice Age itself. For that, however, it is far too considerable, sometimes, as at Huxley Farm, attaining a thickness of several metres; besides, its flora and molluscan fauna are much too rich. It must then be *pre-glacial*, and, as such, is the latest known fossiliferous deposit in the Thames Valley.

The gravel *beneath* the Arctic bed is therefore itself also pre-glacial. The position of the upper gravel just below the 'late-glacial' loam indicates that it is glacial, and where the uppermost layers of the gravel yield huge blocks as they do at Hanwell, west of London, or where they are clearly contorted, there can be no doubt that the layers at any rate at these places were deposited during the Ice Age itself.

The *'late-glacial' loam*, which usually goes by the scarcely geological and frequently inappropriate name of 'brick-earth', belongs to the period of the melting of the inland ice. Here, however, we only have to deal with that part of the loam which during the first stage of the melting was deposited outside the true moraine region or

[1] R. Brice Higgins, Jan. 1914. "Flint Implements of Moustier type and associated Mammalian Remains from the Crayford Brick-earths"; with a note by R. A. Smith: Man, vol. 14, pp. 4–8.

[2] V. Commont, 1912. "Moustérien à faune chaude dans la vallée de la Somme à Moutières-les-Amiens": Congr. internat. Anthrop. Arch. préhist., Genève, p. 291.

[3] Marcel de Puydt, J. H. Nandrin, & J. Servain, 1913. "Le gisement de Sainte-Walburge dans le limon hesbayen": *Liége Paléolithique*, Liége.

Since this paper was written the author has visited the well-known locality Rickmansworth. At the bottom of the old river-gravel, 18–19 feet thick and only a few inches above the Chalk, are here found Chellean, Acheulian, and early, primitive Mousterian, all pre-glacial. This is therefore a new locality for "Mousterian with warm fauna".

[4] S. H. Warren, 1912. "On a Late Glacial Stage in the Valley of the River Lea, subsequent to the epoch of river-drift man": Quart. Journ. Geol. Soc., vol. 68, pp. 213–28.

[5] Here and in the following pages the usual term 'late-glacial' is used for the last glacial deposits in Southern England. This term, however, is correct only when applied *locally*, for if these deposits are considered in connexion with all the deposits of the Ice Age they cannot be described as really late-glacial, the true late-glacial deposits being much later. This question of terminology will be reverted to later on.

outside the periphery of the inland ice, and which, as will be shown later, must have been laid down in a large deep basin formed by the depression of Southern England. This depression was greater towards the north and the east, less towards the south and west, and may have reached as much as 200 feet below the present level.

This loam must therefore have had, and indeed still has, a wide distribution in Southern England, away from the northern boundary of Essex into the valley of the Thames, and along the southern coast right down to the Scilly Isles, where its presence has lately been proved by G. Barrow. We also find its equivalent in the large continuous loam tract in Belgium and in Northern France, of which more later on.

Concerning the loam in the Thames Valley, Mr. H. B. Woodward quite correctly says that this "appears to have been deposited for the most part in tranquil waters and has been described as an inundation-mud". It varies, he says, in thickness "from a few feet to 20 feet or more".[1] A characteristic of it is that it lies without any passage on the older gravel, also that it is not to any noteworthy extent washed out on the surface; whence it may be concluded that the water from the loam basin was emptied out with considerable rapidity, an important circumstance to which there will be occasion to refer later on. In one locality, Green Lane brickyard, at Acton, London, W., I have seen horizontal layers of sand and clay beautifully alternating through the lower part of the loam, here 12 feet thick, but often the fine clay goes right down to the bottom, to the gravel.

While the gravel in the last-mentioned brickyard, as Mr. F. Sadler kindly informs me, yields Chellean implements but never Mousterian, the loam, on the other hand, contains only late Mousterian implements, that is to say, precisely the type which belongs to the maximum of glaciation.

Exactly the same situation as the loam of the Thames Valley is occupied, just outside the moraine district, by the great tract of loam which in North-West Essex extends over the peninsula between the Rivers Stour and Colne.[2] Here too the lower beds may be sandy. The highest points of this clay tract lie between 161 and 187 feet, pointing to a corresponding depression during the deposition of the loam, or more correctly a somewhat greater depression, since the pure loam as a deep-water formation was never deposited on the shore-line itself. This seems to have been the greatest depression that affected Southern England during the stage in question.

On the southern coast of England there have been proved still *older* stages of depression than that during which the loam was deposited, but before considering these a few words may be devoted to the course of the depression taken as a whole.

The fact has already been recalled that England, like the whole of Northern Europe, during an earlier pre-glacial stage lay considerably

[1] H. B. Woodward, 1909. *The Geology of the London District* (Mem. Geol. Surv. England and Wales), see p. 74.

[2] See the Geological Survey drift maps and memoirs, to which reference may also be made for the following account of the Pleistocene deposits in Southern England.

higher than now. The Cromer River to the north, and the Hurd Deep River to the south, of the Straits of Dover are sufficient and clear proofs of this. Men and beasts had then no difficulty in wandering from the continent to England. But it is equally clear that when the former river disembogued to the east of the present coast of Norfolk a sinking of the land was begun. A later, more advanced stage of this sinking has been proved by some borings in the coast district of Belgium: at Ostend, at Leffinghe, south-west of Ostend, and at Petit Crocodile, north of Middelkerke. So long ago as 1884 Gustave F. Dollfus[1] drew attention to the Ostend boring, as indeed it well deserved. Briefly stated, at Ostend at a depth of 22·45–33·5 metres[2] below the surface, which lies only a few metres above the level of the sea, there has been found a rich marine fauna, which, however, is entirely devoid of southern species. From this Dollfus draws the obviously correct conclusion that the North Sea was not yet in connexion with the English Channel. The Straits of Dover did not then exist.

The same was the case at least at the beginning of that considerably later stage of depression to which the so-called 'raised beach' on the south coasts of England and Wales and on the French coast (at Selsey, at Brighton, on Gower, at Sangatte, etc.) bears witness. In the Selsey Beach, for instance, the lower layer yields a marine molluscan fauna with forms of so southern a character that they have now to be sought as far down as the coast of Portugal.[3] This 'raised beach' depression is clearly pre-glacial, while the succeeding depression may be called glacial, since it was during it that the glaciation reached the maximum, while it came to a close with the deposition of the 'late-glacial' loam.

It was during the succeeding *glacial* depression that the marine North Sea fauna, more like the present one, first came down to the south coast of England, where it is observed in the Chichester district, at Oving, and at Goodwood Park. The Straits of Dover are now open, and England is no longer connected by land with the continent. J. Prestwich, however, who came to the same conclusion as long ago as 1865,[4] though by quite a different road, has shown that they were open when the sand that covers the 'raised beach' at Sangatte was deposited; and in so far as this sand really belongs to the older stage, the opening of the Straits must have already been effected during its latter portion. This chronological discrepancy is not great, and entirely disappears if it can be shown that the North Sea fauna migrated to the south coast already during the last stage of the 'raised beach'. Here, nevertheless, we may recall the fact that R. A. C. Godwin-Austen observed "a black band", or, in other words, "an old terrestrial surface," between the pre-glacial 'raised

[1] G. F. Dollfus, 1884. "Le terrain quaternaire d'Ostende et le *Corbicula fluminalis*": Ann. Soc. malac. Belgique, tome 19, pp. 28–54.

[2] The depth in the other localities is less: 12·2–24·9 and 14·8–21·5 metres.

[3] R. Godwin-Austen, 1857. "On the Newer Tertiary Deposits of the Sussex Coast": Quart. Journ. Geol. Soc., vol. 13, pp. 40–72, see p. 54.

[4] J. Prestwich, 1865. "Additional Observations on the Raised Beach of Sangatte, etc.": Quart. Journ. Geol. Soc., vol. 21, pp. 440–2.

beach' at Sangatte and the superjacent layer which belongs to the glacial depression; this surface would imply at any rate a short break in the sinking of the land.[1]

A further interesting observation has been made by A. Bigot at Saint Aubin in Calvados.[2] At a height of 2 metres above high-water level he has found a beach deposit which contains among other marine molluscs *Buccinum grœnlandicum* and *Trophon antiquum*, that is to say, still more northerly species than those known from the south coast of England. Since this beach deposit is covered by the loam, beneath which in other localities Mousterian implements have been found, it indubitably belongs to the deposits of the glacial depression, and shows that the North Sea water which streamed in through the newly opened Straits of Dover straight against the French coast, just before the deposition of the 'late-glacial' loam, was very cold, and considerably colder than it was when the marine fauna of a slightly earlier period came to the south coast of England near Goodwood Park.

The deposits from the two stages of depression, the pre-glacial 'raised beach' stage and the glacial stage, claim further attention. Both have been exhaustively described by J. Prestwich.[3] On the Gower Peninsula in South Wales the 'raised beach' is stated to reach a height of 25 feet above O.D.,[4] at Brighton 24 feet,[5] at Sangatte 10–12 feet,[6] and at Menchecourt near Abbeville, where the ground lies about 15 metres above the sea, the corresponding marine beds, resting on deposits with Chellean implements, rise to 24 feet above O.D.[7]

Various observations on the 'raised beach' render it possible to determine the age of its formation with fair accuracy. The fact, made known by R. H. Tiddeman, that the 'raised beach' on the south coast of Wales is covered by moraine proves it to be distinctly pre-glacial. In two caverns, Bacon Hole and Mitchin Hole on the Gower Peninsula, are found various mammalian remains, and among them *Elephas antiquus* and *Rhinoceros leptorhinus*, both in the marine sand of the 'raised beach' and immediately above it.[4] These fossils indicate an age corresponding to that of Grays or Ilford, but distinctly older than that of Erith-Crayford. Acheulean finds in the middle of the 'raised beach' at Brighton show that the beach cannot be older than Acheulean,[5] but that stage was not of particularly long

[1] R. A. C. Godwin-Austen, 1866. "On the Kainozoic Formations of Belgium": Quart. Journ. Geol. Soc., vol. 22, pp. 228–54, see p. 253.

[2] A. Bigot, 1897. "Sur les dépôts pleistocènes et actuels du littoral de la basse Normandie": C.R. Acad. sci. Paris, tome 125, pp. 380–2.

[3] J. Prestwich, 1892. "The Raised Beach and 'Head' or Rubble-Drift of the South of England, etc.": Quart. Journ. Geol. Soc., vol. 48, pp. 263–343.

[4] A. Strahan *et alii*, 1907. Mem. Geol. Surv. England and Wales, Expl. Sheet 247, Swansea, see p. 118.

[5] Reginald A. Smith, 1915. "Prehistoric Problems in Geology": Proc. Geol. Assoc., vol. 26, pp. 1–20, see p. 3.

[6] J. Prestwich, 1851. "On the Drift at Sangatte Cliff near Calais": Quart. Journ. Geol. Soc., vol. 7, pp. 274–8, see p. 278.

[7] J. Prestwich, 1894. "On the Evidences of a Submergence of Western Europe, etc.": Phil. Trans., vol. 184, pp. 903–84, see p. 910.

The Chellean finds from the low-water beach at Havre belong, on the other hand, to an earlier period, namely, that of the elevation of the land. See Bull. Soc. amis sci. nat. Rouen, vol. 34, pp. 129–32, 1898.

duration and comes immediately before the Mousterian stage, which is in the main the equivalent of a later geological stage, namely, the maximum of glaciation. At Menchecourt the 'raised beach' layer rests, as just said, on Chellean, and must therefore belong either to a later stage of Chellean or to the Acheulean. Lastly, as regards the erratics in the 'beach', they certainly bear witness to floating spring ice or perhaps also to floating icebergs (most probably the inland ice had already invaded Scotland), that is to say, they bear witness to *advancing* cold, but in no way, as some have tried to maintain, to retreating cold. All these observations concerning the age of the 'raised beach' are therefore not contradictory to one another and can be brought into complete agreement.

We now proceed to a somewhat more detailed account of the deposits of the glacial depression, which are undeniably of much interest. They consist of shell-bearing marine sand, gravel, which on the geological map sometimes is called 'valley gravel', partly rounded in the usual way, partly but little rolled and 'angular' ('coombe rock,' 'rubble drift,' 'head'), the two kinds of gravel being sometimes mixed, as well as loam, which has no fossils except for the very rare land shells that have been washed down into it.

These deposits are found along the whole south coast of England wherever the shores were not too steep to prevent their deposition, and have also been proved on the French coast at Sangatte. They are particularly well developed in the district round Chichester, Sussex. The formerly depressed region is here spread out as a remarkably fine and level sea-platform, the northern limit of which proceeds right across the map of the district in an almost straight east and west direction and immediately strikes one as an evident shore-line. In Goodwood Park the marine limit appears to ascend to a height of 157 feet above O.D. The marine fauna, so far as it is as yet known from the fine section at the last-named locality, is a North Sea fauna "like that now living on the south coast of England", with *Cardium edule*, *Mytilus edulis*, *Tellina balthica*, *Trophon* sp., as well as a newly found lamellibranch from the bottom layer of the locality, 'tabular concretions,' a small example kindly determined for me as a species of *Modiola* by Mr. R. B. Newton of the British Museum. "At first sight," says Prestwich,[1] "these sands appear unfossiliferous, but a short search shows the presence of a number of minute and very friable shells from ¼ to ½ inch long, and which proved to be the young, apparently, of the common mussel. I also found a few full-grown specimens of this shell and of the common edible cockle; but they all fell to pieces when touched." This I believe to depend on the fact that the water here on the south coast of England, which had become more and more cold during the glacial depression, now at last during the Goodwood Park stage became altogether too cold and also altogether too fresh to permit of the molluscan fauna which lived in it attaining its full development.

As regards the gravel, Godwin-Austen has remarked that it occurs,

[1] J. Prestwich, 1859. "On the Westward Extension of the old Raised Beach of Brighton, etc.": Quart. Journ. Geol. Soc., vol. 15, pp. 215–21, see p. 219.

or at least may occur, as two distinct layers, an observation the correctness of which I am able to confirm from the gravel-pits in Portfield immediately east of Chichester. It is most natural to regard the lower bed as deposited during the depression of the district, and the upper bed during the elevation which immediately succeeded.

The loam, the uppermost and last deposit during the period of depression now in question, occurs at some distance below the uppermost shore-line, in consequence of the fact that, especially on an open coast, it could only be deposited in deep water. It has the usual aspect of the 'late-glacial' loam. In Bognor it is said to be as much as 14 feet thick.

On the south coast of England the loam cannot, to any considerable extent, have arisen from the inland ice, which lay at too great a distance, but had as a rule a less remote origin, namely, from the south coast itself.

The glacial deposits now in question have been traced by Mr. Clement Reid from the Chichester map-sheet westward over the map-sheets of Fareham, Southampton, Bournemouth, and Dorchester, where its upper limit descends to a somewhat lower level. In the area of the Torquay map-sheet it may be observed in the shore deposits at Hope's Nose, where, however, it only ascends to 48 feet above O.D.; and west of Brixham Harbour, between there and Churston Cove, Mr. W. A. E. Ussher has directed my attention to a small but well-developed sea-platform covered with loam and reaching a height of about 50 feet.

Cornwall with its steep shores has a deposit called 'head', which follows the coastline and must therefore be a shore deposit. Concerning this and other coast deposits of Cornwall, Mr. Clement Reid has the following, as it seems to me, well-grounded remarks: "The succession in these Pleistocene deposits corresponds so exactly with that found along the Sussex coast that we cannot refrain from thinking that the strata are of the same date. The 'head' of the Cornish coast seems to be equivalent to the 'Coombe rock' of the Sussex coast." [1]

West of Cornwall lie the Scilly Isles, and here too is found the 'late-glacial' unfossiliferous loam as a thin deposit, and G. Barrow has been able to establish the fact that it has precisely the same aspect as the loam on the coast of Brittany. Here it contains 'scratched stones', which show that it is "essentially a glacial deposit".[2]

Eastwards from Chichester the gravel and loam deposits are proved to occur at various places on the coast, such as Brighton and Eastbourne. I have myself seen the loam in the neighbourhood of Hastings, and Professor X. Stainier, of Ghent, who there accompanied me, remarked on the extraordinary resemblance to the Belgian 'limon hesbayen'. At Sangatte, Prestwich observed both gravel and loam,

[1] C. Reid & E. M. Reid, 1904. "On a probable Palæolithic Floor at Prah Sands (Cornwall)": Quart. Journ. Geol. Soc., vol. 60, pp. 106–12, see p. 110.

[2] G. Barrow, 1906. Mem. Geol. Surv. England and Wales, Expl. Sheets 357 and 360, "Isles of Scilly," see pp. 27–8.

the latter with land molluscs washed into it, covering the older 'raised beach' up to 80 feet above O.D., a figure which cannot be regarded as representing the limit of its extent.[1]

The circumstance that the coast deposits along the south coast of England lie at a much lower level westwards than they do eastwards at once renders it probable that the depression of the land during which they were laid down was greater on the Continent than in England, and this in fact receives further confirmation. Thus, in Northern France, according to J. Ladrière, the 'late-glacial' loam is found up to a height of 240 metres[2] (=787 feet). The loam, therefore, has a much wider distribution on the Continent than in England, and stretches from Hofstade in North Belgium down to Finisterre in the south, where it is found on the northern side of the peninsula, but is wanting on the island of Ouessant as well as on the south side of the peninsula east of this,[3] while it covers the Channel Islands, which were "completely submerged" during its deposition.[4] The basin in which this peculiar loam was laid down was therefore very large and in parts also very deep.

As already stated, the loam contains no fossils. If this basin had been filled with sea-water this would be quite impossible. Almost equally impossible would it be if it contained ordinary fresh water. There remains, therefore, no other possibility than that the water was glacial, coming from the inland ice and the tundras, that the basin was closed in the north by the inland ice itself and in the south by an elevation of the sea-floor from Finisterre north-westwards, an upward pressure which may be regarded as having balanced the downward pressure and lowering of the land which was effected by the inland ice both in England and on the Continent along and in front of its extreme limit. These contemporaneous changes of level in two opposite directions can be explained only in one way, namely, as the direct and indirect result of the pressure of the inland ice. The succeeding post-glacial changes of level also find their full explanation in the same pressure and in the removal of that pressure. Such an explanation has appeared to be the only one that can be applied to the interpretation of the glacial and post-glacial changes of level in Scandinavia, in parts both rapid and great and followed by distinct wave-motions of the surface. Here we need only recall the fact that the glacial strand-walls in Northern Sweden, nearest to the former centre of the inland ice, now lie as far up as 260 metres (=853 feet) above the level of the Baltic, and that this huge and rapid elevation took place in connexion with, and immediately after, the melting of the inland ice, that is to say, as a consequence of the sudden removal of the pressure of the ice. Beside these Scandinavian changes of level, the elevation of the continental sea-platform south of the

[1] J. Prestwich, op. cit., 1851, p. 275 (the section), and op. cit., 1865, p. 442.

[2] J. Ladrière, 1891. "Étude stratigraphique du terrain quaternaire du Nord de la France": Ann. Soc. géol. Nord, tome 18, pp. 205–75, see p. 212.

[3] C. Barrois, 1897. "Note sur l'extension du limon quaternaire en Bretagne": Ann. Soc. géol. Nord, tome 26, pp. 33–44, see p. 39.

[4] A. Collenette, 1893. "The Raised Beaches, Cliff and Rubble-heads of Guernsey": Trans. Guernsey Soc. Nat. Sci., 1892, pp. 219–35.

English Channel up to a height of some 500 feet, as here accepted, may be regarded as comparatively small.

The view here expressed lays no claim to novelty. In 1908 A. L. Rutot upheld the necessity of supposing a 'lac hesbayen' in which the 'limon hesbayen' or loam must have been deposited; he has moreover printed a sketch-map indicating the limits of the Hesbayan lake,[1] certainly quite unlike the limits of the glacial freshwater basin postulated above; and Rutot himself, as he told me, had his predecessors.

The deposition of the loam cannot have required a particularly long time. In England I have not succeeded in finding any place where the yearly deposit was clearly enough shown to be estimated. On the other hand, in Belgium and Northern France there are many places in which it has been possible to make such an estimate. There the thickness of the yearly deposit varies between 1 cm. and 4 cm., and there is only one locality in which I have found it less than 1 cm. Let us now apply to the deposit of loam in England the last-mentioned figure, which is the same as I have been accustomed to use in Sweden when attempting to make merely a rough estimate of the time of formation of the late-glacial clays in that country. If, further, we take the previously given figure of 20 feet (or 6 metres) as close upon the greatest thickness of the 'late-glacial' loam in the Thames valley, then we reach a result of only 600 years as the approximate period for the deposition of this loam.

Before leaving the deposits which belong to the glacial period of depression we may with a few words contribute to a clear comprehension of the angular gravel (the so-called 'coombe rock', 'rubble drift', or 'head'). The upper, most angular, gravel is regarded as in large part deposited when the 'late-glacial' basin was emptied. This must have been a somewhat rapid process. The loam, as previously remarked, has not been rehandled to any great extent. It is not sandy on the surface, and the gravel itself shows that it was not exposed to the work of the waves for any lengthy period. It may here be worth referring to Prestwich's remarks on the 80 feet of rubble and gravel at Sangatte, especially with reference to the upper 20 to 25 feet in which there is a "preponderance of angular flints". Following a similar opinion to that expressed by Roderick Murchison, he sums up his view concerning the deposit in question in this well-considered verdict:[2] "The action which led to the accumulation of this Drift was sudden, powerful, tumultuous, not of long continuance, and suddenly arrested." This is indeed "hitting the nail on the head" in very few words.

The 'creeping-soil' theory has, as is well known, been applied more than once to the interpretation of the angular gravel. But it is altogether out of the question thus to explain a piling up of from 20 to 25 feet or still more of such gravel. Besides, if nothing more was required for this formation than the winter cold of the Ice Age

[1] A. Rutot, 1908. "Les deux grandes provinces quaternaires de la France": Bull. Soc. préhist. France, 1908, p. 8.

[2] J. Prestwich, op. cit., 1851, p. 276.

and the melting action of its summer warmth, why should this gravel not be found over the whole of Southern England, instead of being confined to the glacial depression-districts of the south coast?

(*To be concluded in our next Number.*)

III.—Note on a Fore-paddle of *Metriorhynchus* from the Oxford Clay of Peterborough.

By Charles W. Andrews, D.Sc., F.R.S. (British Museum, Nat. Hist.).

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In the description of the skeleton of *Metriorhynchus* given in vol. ii of the Catalogue of the Marine Reptiles of the Oxford Clay, very little could be said about the fore-limb. The only parts then known were a number of humeri and, in one or two cases, some small disc-like bones which were regarded as the radius and ulna: the most complete fore-limb was figured on p. 172 of the volume quoted. In order in some degree to fill this gap a short account was given (tom. cit., Introduction, p. xiii) of an imperfect fore-paddle of a specimen of the closely related *Geosaurus gracilis* from the Solenhofen limestone. This beautiful skeleton, originally described by V. Ammon (*Geognostische Jahreshefte*, vol. xviii, p. 12), has recently been acquired by the British Museum, and a photograph of it is given as a frontispiece to vol. ii of the Catalogue of Oxford Clay Reptiles. The specimen is beautifully preserved, and is remarkable for showing the outline of the tail-fin and other traces of the soft parts. Unfortunately for the present purpose the fore-limb is represented only by impressions of the bones, and no trace of the humerus can be seen, but still a good idea of its short paddle-like structure is given: this is shown in figure 1.

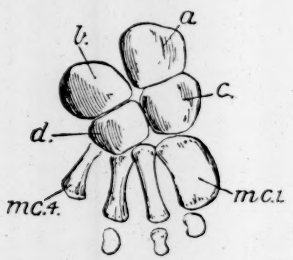

Fig. 1.—Fore-paddle of *Geosaurus gracilis*. *a*. radius; *b*. ulna; *c*. radiale; *d*. ulnare; *mc*. 1–4, metacarpals. R 3948. Nat. size. From *Catalogue of the Marine Reptiles of the Oxford Clay*, p. xiii.

It will be seen that proximally there are two pairs of disc-like bones, the homologies of which are not certain. Ammon regards the proximal pair (*a* and *b*) as being the radius and ulna, the distal pair (*c* and *d*) as the radiale and ulnare. Fraas in his account of the fore-limb of *Geosaurus* adopts the same view (*Palæontographica*,

vol. xlix, 1902, p. 56, pl. viii, fig. 3), but in his specimens the bones of the proximal pair are much larger than the distal. If this interpretation is correct, then the distal carpals must have disappeared or, as seems unlikely, have fused with the proximals. The first metacarpal is an expanded plate, the other three rod-like; the fifth is wanting in Ammon's specimen, but is figured by Fraas, who also shows the number of phalanges as 2, 3, 4, 3, 2, but this is very uncertain; in *Geosaurus gracilis* Ammon figures a single phalange in each of the first three digits.

Recently Mr. A. N. Leeds has collected from the Oxford Clay of Peterborough a nearly complete left fore-limb of *Metriorhynchus*, together with portions of the right.

Fortunately the clay in which the left carpals and proximal ends of the phalanges lay has been preserved, and from the impressions of the bones their position can be determined. On the right side the second, third, and fourth metacarpals are in situ in the matrix, and there is an impression of the proximal end of the fifth. The humerus, radius, and ulna on both sides are unfortunately completely freed from matrix, and their exact relative position remains doubtful. Figure 2 shows what is regarded as the most probable arrangement of the bones of the left paddle (p. 446).

The *humerus* (*h.*) is much compressed from before backwards, and its preaxial border is produced into a strong deltoid crest, forming a triangular expansion and terminating in a small tuberosity. The head is oval and is strongly convex. Beneath the deltoid crest the shaft is a flattened oval in section, and the distal articulation is a slightly convex facet occupying the whole of the end of the bone and running up a little on to the preaxial border.

The *radius* (*a*) is a flattened plate the edge of which is thickened, and bears an articular facet on its upper inner border and another at its distal end. In front of these facets the body of the bone forms a large flattened expansion, projecting considerably preaxially. This bone is regarded as the radius (1) on account of its larger size, there being a tendency for the preaxial bones of a paddle to become enlarged, a condition here seen also in the radiale and first metacarpal; (2) because its distal articulation agrees very well with the upper articular surface of the radiale.

The bone here regarded as the *ulna* (*b*) is smaller than the radius. At its upper end it is much compressed and bears an oblique facet for the humerus; its posterior border is produced into a thin, sharp process, marked with striæ directed towards its apex—possibly this served for the attachment of a strong tendon. Distally the bone narrows and thickens, terminating in a rounded facet for the ulnare.

As already remarked, the exact relations of the radius and ulna to one another and to the neighbouring bones are uncertain, they being freed from the matrix, but in the case of the carpals and metacarpals the case is different, the bed of matrix in which they lay being preserved. The *radiale* (*c*) is the larger of the two carpals; its proximal border is thickened and bears a straight articular surface for the radius; its anterior border is convex, while the posterior is concave, and bears at its lower end a facet for the ulnare. Distally it

articulated with the plate-like first metacarpal and perhaps partly supported the second.

The *ulnare* (*d*) is an oblong bone articulating with the ulna proximally and having a facet at the lower end of its anterior border for union with the radiale: distally it supported the third, fourth, and fifth metacarpals and to some extent the second.

The first metacarpal (*mc.I.*) is a thin, much expanded bone, probably triangular in outline when complete: it articulates with the convex border of the radius only. The second metacarpal, which is rather longer, is a narrow, compressed bone, expanding a little at its upper

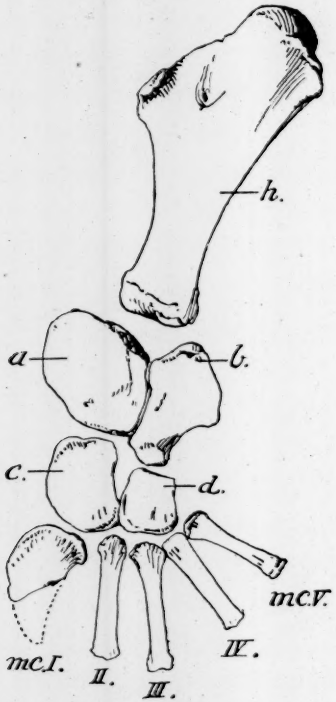

FIG. 2.—Left fore-paddle of *Metriorhynchus*. *a*. radius; *b*. ulna; *c*. radiale; *d*. ulnare; *h*. humerus; *mc*. I–V, metacarpals. Two-thirds nat. size.

end, which articulated between the radiale and ulnare. Distally it terminates in a sharp edge and probably had no phalange articulating with it. The third metacarpal is larger but otherwise similar: it articulates with the ulnare only. The fourth is about the same length as the second, but is considerably more slender. The fifth is about as long as the fourth, but has a more slender shaft. It has a marked expansion at each end, and distally bears a facet presumably for a phalange, the only one which appears to have been present.

The paddle of *Metriorhynchus*, as compared with that of *Geosaurus*, does not seem to have undergone such extreme modification especially

in its proximal region: thus the humerus is still quite recognizably Crocodilian, while that of *Geosaurus*, figured by Fraas, is not. In the case of the radius, and more particularly the ulna, there are still traces of their condition as long bones, while in *Geosaurus* this is not the case. The carpals and metacarpal are similar in both genera, but the phalanges seem to have undergone most reduction in *Metriorhynchus*.

In most reptiles in which the fore-limb has become paddle-like it tends also to become larger, this enlargement being frequently accompanied by additions to the number of bones composing it. Thus, not only is it usual for the number of phalanges to be increased, sometimes very greatly, but additional elements may appear in the carpal region, e.g. in *Tricleidus*. In *Metriorhynchus*, on the other hand, the paddle-like modification was acquired while the limb was undergoing reduction, and in this case the number of elements has been much reduced, the phalanges having nearly, and the distal carpals entirely disappeared. The limb had already become so small that it can have been of little use in swimming or even in balancing.

Some dimensions (in millimetres) of this paddle are given below:—

Humerus:	length	67
	width of upper end	21
	width at deltoid crest	(approx.) 27
	width at distal end	15
Radius:	greatest length	22
	greatest width	26
Ulna:	greatest length	26
	greatest width	15
Radiale:	greatest length	19
	greatest width	15
Ulnare:	greatest length	14
	greatest width	12
Length of metacarpal	I	(approx.) 19
	II	23
	III	26
	IV	22
	V	21

The two coracoids and the left scapula are also preserved, but they do not seem to differ in any marked respect from specimens described in the Catalogue.

IV.—Moine Pebbles in Torridonian Conglomerates.

By J. W. Gregory, D.Sc., F.R.S.

THE relation of the Torridon Sandstone to the Moine Gneiss or 'Eastern Schists' is one of the primary questions in the geology of the Scottish Highlands. These two widespread series of rocks occur on opposite sides of the great overthrusts in North-Western Scotland; and another remarkable feature of their distribution is that though the Torridon Sandstone often rests directly upon the Lewisian Gneiss, it never occurs on the Moine Gneiss. The view has therefore been suggested that the Moine rocks are the eastern metamorphosed continuation of the Torridonian. Some altered Torridon Sandstones certainly resemble the rocks of the Moine Series.

Dr. Horne,[1] in his address to the British Association in 1901, quoted the authority of Dr. Teall and Dr. Peach for the resemblance of altered Torridon Sandstone to the Moine; and he again remarked this resemblance in the memoir on the North-West Highlands.[2] The late W. Gunn went further, and in the same work claimed (p. 612) that "east of Dundonnell good evidence can be adduced that altered Torridon Sandstone has entered largely into the composition of the Eastern schists". The recent memoir on the Fannich Mountains represents some of the flaggy granulites of that district as due "to the crushing of Torridon Grit".[3]

As the Moine and Torridonian rocks both originated as quartzo-felspathic sediments, the fact that they give rise to similar rocks under the influence of dynamo-metamorphism does not prove that they are of the same age. The claim that the Moine rocks are altered Torridonian rests upon two main arguments. First, the absence of the Torridon Sandstone from the eastern side of the overthrusts, whereas, if it were a later formation, some outlier upon the Moine Series might be expected. The weight of this argument is lessened by the facts that between Loch Alsh and Glenelg typical representatives of the Moine Gneiss and of the Torridon Sandstone are faulted against one another, and that the Cambrian rocks also are absent from the surface of the Moine Series in the area east of the overthrust band.

The second and weightier argument rests on the view that no pebbles of the Moine rocks occur in the Torridon conglomerates; and if this fact were confirmed it would support the view that the Torridon Sandstone is not a later formation than the Moine. In the Survey Memoir on the North-Western Highlands, Dr. Teall's chapter on the petrography of the Torridon Sandstone contains an account of the included pebbles (op. cit., p. 283); he points out that schistose and highly metamorphic rocks are rare in the Torridonian conglomerates except in the basal breccias, which are full of Lewisian fragments. He mentions seven or eight pebbles from the Torridon Sandstone in the Survey collection, of which all but two or three are quite different from the Moine rocks; the others are "mainly composed of quartz showing marked signs of dynamic action", and these characteristics give no adequate clue to the origin of these pebbles. Hence the Survey memoir appears to support the absence of Moine rocks from the Torridonian conglomerates. So also does the more recent memoir on Sheet 92 (1913, p. 40), which gives a list of pebbles in the Torridonian beds, including "grit, quartzite, chert, jasper, felsite, and quartz porphyry, which are quite unknown in the Lewisian gneiss"; but it does not mention any rock that was regarded as even probably Moine.

[1] J. Horne, 1901. "Recent Advances in Scottish Geology": Rep. Brit. Assoc., 1901, p. 622.

[2] *The Geological Structure of the North-West Highlands of Scotland* (Mem. Geol. Surv. Great Britain, 1907), p. 468.

[3] *The Geology of the Fannich Mountains and the Country around Upper Loch Maree and Strath Broom* (Sheet 92, Mem. Geol. Surv. Scotland, 1913), p. 81.

On several occasions I have found pebbles in the Torridon Sandstone which appeared indistinguishable from the Moine rocks; and I recently collected several from a locality which affords an especially useful test. They were obtained on the northern shore of Little Loch Broom, a quarter of a mile west of Badralloch, from cliffs of the Applecross or middle division of the Torridon Sandstone. The conglomerates there contain many pebbles which exactly resemble the typical rocks of the Moine Series. Dr. Teall has kindly examined five of the specimens and slides cut from them; and he writes, "the three rocks (M 1, M 2, and M 5) are undoubtedly of Moine type, and the two quartzose rocks (M 3 and M 4) are like rocks associated with granulitic gneisses of the Moine group. I believe that all five rocks could be matched by rocks from areas mapped as Moine." The specimens have also been examined by Dr. Horne, who says, "there can be no doubt that they are typical siliceous granulites of Moine type." Mr. Tyrrell independently examined the slides, and he also says that three of the five specimens are typical granulitic Moine rocks; the other two, he remarks, are quartzites without distinctive features.

Dr. Horne remarked that it is possible such rocks might occur among the altered sediments of the Loch Maree type which are referred to the Lewisian.[1] This possibility seems remote. The nearest exposure of the Lewisian rocks is about $2\frac{1}{2}$ miles from Badralloch on the opposite side of Little Loch Broom, and in that district they are the normal type; and the altered sediments which are referred to the Lewisian are 15 miles to the south. The Moine rocks of Loch Broom are well exposed about five miles from Badralloch, though this proximity may be due in part to the overthrusting. The Moine rocks nearest Badralloch include both the granulitic micaceous gneiss and granulitic quartzite which occur as pebbles in the Torridon conglomerates. The quartzitic type has been described by Gunn (Geol. Surv. Memoir, 1907, p. 611), who says that in this district "there are also highly siliceous and massive kinds which approach the nature of quartzite, and contain little mica of any kind". These rocks are well exposed on the road south-east of Ullapool, near the head of Loch Broom.

The Torridonian pebbles of Little Loch Broom therefore differ from the local Lewisian rocks and are indistinguishable from the two typical rocks of the nearest outcrop of the Moine Series. Hence it appears more reasonable to regard these pebbles as derived from the similar local Moine rocks than to refer them to a hypothetical Lewisian source three times as far distant.

It may be urged that the presence of Moine pebbles in the Torridon Sandstone does not prove that all the Moine is pre-Torridonian; for the Moine may consist of two elements—(1) pre-Torridonian Moine rocks, from which these pebbles have been derived; and (2) Torridon Sandstone which has been altered into such Moine-like granulitic gneisses that they have been mapped by the Geological Survey as

[1] The Fannich memoir, Sheet 92, 1913, p. 9, remarks, however, that the relations of these altered sediments "to the members of the Fundamental Complex have not been definitely determined".

Moine. The suggested double age and origin of the Moine need not be discussed in this paper, the purpose of which is to show that the Torridon Sandstone does contain pebbles from the Moine.

The derivation of these pebbles from the Moine is consistent with the evidence of the felspathic constituents of the Torridon Sandstone. Dr. Teall remarked (North-West Highlands, 1907, p. 285) that the characteristic felspar of the red sandstones or arkoses in the Torridon Sandstone is microcline, which is not the typical felspar of the Lewisian, though it is often abundant in the Moine.

If the Torridon Sandstone includes pebbles of the Moine rocks, it must be a younger formation than the Moine Series.

V.—Polar Climates.

By R. M. Deeley, M.Inst.C.E., F.G.S.

PERHAPS one of the most unexpected facts concerning the geology of the Polar regions is the almost entire absence of pre-Quaternary rocks composed of glacial detritus, and the presence there mainly of sediments containing floras and faunas indicating warm climatic conditions. This is true of the rocks composing the Antarctic Continent as well as of the land masses in the neighbourhood of the Arctic Sea. Indeed, it is not until rocks of late Tertiary or Quaternary times are reached that we get any signs of continuous frigid conditions at the Poles.

However, there are rocks of several ages in many parts of the world which show that frigid conditions have existed in low latitudes, and even near the Equator itself, in pre-Quaternary times. Generally speaking, however improbable it may seem, the facts indicate that in pre-Quaternary times the world was warm or temperate throughout the greater portion of the time from the Equator to the Poles, but that there were occasional cold periods which affected areas in both high and low latitudes. In Quaternary times, however, the Polar regions were frigid throughout the whole interval, and have remained so; but there were also much colder intervals which affected all latitudes. Here we clearly have two phenomena resulting from different causes to deal with: the one an effect which caused occasional cold periods affecting the whole earth more or less, and the other a condition which, until recent times geologically, kept the Polar areas, like the rest of the earth, temperate or tropical in climate. Indeed, climatic zones would appear to be of comparatively recent development.

This almost complete absence of climatic zones in the past has been commented upon by F. Frech,[1] who points out that in 80° North latitude there prevailed in the past a temperate, indeed a warm temperate climate, for in Spitzbergen we have a fossil flora of evergreen growths and trees with acicular leaves similar to those of the Mississippi district, such as the swamp cypress. He contends that the climatic arrangement of the present day originated in a geologically recent time; but points to signs of the brief development of climatic

[1] Zeitschr. des Ges. für Erdkunde zu Berlin, 1902, pp. 611–29, 671–93.

zones at earlier periods of the earth's history. Eckhardt[1] also remarks that the geological contrasts up to the middle of the Cainozoic were not so pronounced as they are now, and it may be said with perfect safety that the climate of the Tertiary and the preceding geological epochs, especially in the Northern Hemisphere, had on wide stretches in the higher latitudes an apparently more insular character with less temperature extremes than the present, above all with warmer winters. Indeed, the late Tertiary earth movements seem to have resulted in a land distribution which caused a radical change in the climates of high latitudes.

The great uniformity of the forms of life flourishing at the same time in very different latitudes in past ages has greatly simplified the task of the correlation of widely separated rock formations, and what is often regarded as the mingling of boreal, temperate, and tropical forms of life in late Tertiary or Pliocene deposits, as at St. Erth, may be explained by regarding them all as warm temperate forms, the descendants of some of which have survived as temperate, some as tropical, and some as boreal forms, whilst some have become extinct. However, even before Red Crag times there were probably portions of the Arctic Sea cold enough to give rise to boreal forms of mollusca, etc., which spread south as the temperature fell.

With the causes that may have led at times to the lowering of the temperature of the whole earth I do not purpose to touch upon at all here. My desire is to call attention to certain considerations which may elucidate the difficulties that are met with in the study of Polar climates of past ages as shown by the geological record. Other hypotheses have been brought forward to account for the facts; but they have not received any general support and would take up too much space to fully discuss here.

It is agreed that at the present time ocean currents have a very powerful effect upon climate. They carry immense quantities of heat from hot to cooler regions, and warm regions are to some extent cooled by cold Polar currents. But although the heat is mainly carried from latitude to latitude by the water of the ocean, the direction in which the ocean currents travel is dependent upon the direction of the winds. If heat were not carried from latitude to latitude by ocean currents and the winds, the differences of temperature between localities in the same latitude but in different longitudes would be much less marked than they are. Such cold currents as flow from the Polar areas are caused to do so by the winds. If the surface winds travelled wholly towards the Poles the return colder currents would be deep-sea ones.

Labrador is in the same latitude as England, yet the climates are very different, and the difference is due to the fact that Western Europe enjoys south-westerly winds, especially in the winter, whilst Labrador is chilled by winds from the north. Bouvet Island and the Isle of Man are in practically the same latitude, yet the former is now glaciated down to the sea-level.

From the point of view of climate the direction in which the winds

[1] *Die Wissenschaft*, xxxi, Brunswick, 1909.

blow is of the utmost consequence. But it cannot be said that there is any general agreement among meteorologists as to the reasons why the general winds of the earth blow in the directions they do. If the flow were due to the temperature gradients as they now exist on the earth's surface, then the cold air at the Poles should flow towards the Equator as north-easterly winds in the Northern, and as south-easterly winds in the Southern Hemisphere, and there should be currents in the higher atmosphere moving towards the Poles. We should then have a belt of lowest pressure in Equatorial regions, and two high-pressure areas, one over the North Pole and another over the South Pole.

But the prevalent winds do not uniformly blow as above indicated. There is the low-pressure belt, and the winds as above described, in Equatorial regions; but instead of these winds coming from the Polar regions they come from two fairly continuous high-pressure belts at latitudes 30° north and south of the Equator.

In higher latitudes in the Northern Hemisphere the winds generally flow polewards as south-westerly winds at the earth's surface and north-westerly winds in the higher atmosphere. These are, of course, the general winds. In many continental areas, such as the Asiatic one, the change of temperature with change of season is very great, and we get such winds as the monsoons, which do not blow as do the trade winds or the prevalent winds of middle latitudes. In the Southern Hemisphere the north-west winds of middle latitudes blow much more regularly than do the south-west winds of the Northern Hemisphere.

Many theories have been propounded to account for these apparently anomalous winds of middle latitudes; but not one of these theories has received anything like general support, for they all fail in some respects to account for the facts. That a correct explanation of the circulation of the atmosphere should be found is most important from a climatological point of view, for such a theory may enable us to predict what effects would be produced if certain geographical changes occurred.

I have lately attempted to base a theory [1] upon the contentions of Halley and Hadley; but instead of considering the winds as blowing in accordance with the surface temperature gradients, they are regarded as being due to the horizontal temperature gradients of the whole thickness of the atmosphere. Recent soundings by registering balloons for ascertaining the temperature of the atmosphere have shown that the temperature of the upper atmosphere is greater in high latitudes than it is over the Equatorial regions. This is a very surprising fact, and if the temperature gradient of the upper atmosphere should be proved by further observation to be as great generally as the many hundred soundings already made show, then the upper temperature gradient should overpower the lower temperature gradient in middle latitudes and cause the lower winds of middle latitudes to move *towards* the Poles.

It is now recognized that the atmosphere may be divided into two

[1] *Phil. Mag.*, July, 1915, pp. 13–33.

distinct layers; a lower troposphere and an upper stratosphere. In the troposphere, as we ascend, the temperature falls at a rate which closely agrees with that of rising and adiabatically expanding moist air, i.e. *about* 0°·5 C. for each 100 metres of rise near the earth's surface. At Batavia,[1] about 7° south of the Equator, it falls somewhat irregularly until a height of 17 kilometres is reached, where the temperature has been found to be −89°·6 C. At 26 kilometres the temperature has risen to −57°·2 C. On the other hand, at Pavlovsk, near Petrograd,[2] in about latitude 59° 40′, the lowest temperature, the mean for the year, was reached at a height of 11 kilometres, and was only −53° C., rising to about −42 C., at 19 kilometres.

The following table shows the heights and temperatures at these two places:—

Height in km.	11	16	19	26
Batavia . . .	−45°	−86°·1	−78°·1	−57°·2
Pavlovsk . .	−53°	−48°·0	−42°·0	

We thus have opposing temperature gradients in the troposphere and stratosphere respectively. The upper side of the troposphere is that point where the temperature either only changes very slowly with increasing height or actually gets warmer as we rise. Its level is much higher in the Tropics than in Polar areas or middle latitudes, and is lower over low-pressure areas than over high-pressure areas. The upper layer is the stratosphere, and it rests upon the troposphere. The reason why the stratosphere in high latitudes has such a high temperature we need not here discuss.

Now if the lower atmosphere, or troposphere, should, from any cause, get warmer in Polar regions, then less opposition would be offered to the flow of the upper atmosphere towards the Equator, and the winds blowing towards the Poles from the high-pressure belts would be strengthened. Such warming of the troposphere in high latitudes would still further decrease the surface temperature adverse to winds blowing from the high-pressure belts at latitude 30° towards the Polar regions. There would thus be brought into operation a secondary effect which would powerfully assist still further to raise the temperature in high latitudes.

Warm seas in Polar regions would mean less cold conditions in the ocean and sea bottoms and would favour the existence of certain kinds of life at greater depths than that at which they now exist.

At the present time the South Polar area is occupied by a continent which is placed nearly concentrically with the Pole. The collection of snow and ice upon this land area keeps the troposphere temperature low, even in summer, and it here contends on fairly equal terms with the opposing temperature gradient in the stratosphere. Outside the Antarctic Continent, however, we have the seas warmed by the prevalent north-westerly winds. Over the sea, therefore, the temperature of the troposphere is less in conflict with that of

[1] W. van Bemmelen, *Nature*, March 5, 1914, p. 6.

[2] Gold, Meteorological Office Geophysical Memoir, No. 5, 1913 (M.O., No. 210*e*).

the stratosphere, and on this account the great cyclonic belt of middle latitudes is maintained.

In the Northern Hemisphere the geographical conditions are the reverse of those in the south. The North Polar area is a partially ice-covered water area, the temperature of which is never excessively low because the ice covering the sea is thin. The lowest temperatures occur over Siberia at Verkhoyansk. But this water-covered area is largely surrounded by land, and the warm ocean currents have only partial access to it. The surrounding land areas also result in the production of low winter temperatures, and the formation of one great cyclone such as that of the Southern Hemisphere is prevented by the irregular arrangement of the land and water areas. However, over the Pacific and Atlantic Oceans, where they approach the North Polar area, two cyclonic centres are formed which remain powerful in the winter. In the winter there are also high pressures over Asia, and south-westerly winds prevail between them and the North Atlantic depression. In the summer low pressures prevail over Asia, and the gradients for south-westerly winds over Europe are less steep.

The conditions existing in both hemispheres thus favour frigid Polar conditions. But the present arrangement of the land masses in the Northern Hemisphere is not such as existed in pre-Quaternary times. Many of the sedimentary rocks of Central North America, East Asia, and Mid-Europe are of ages ranging from Archæan to Miocene times. Bailey-Willis[1] has constructed a series of maps showing the areas in North America which were at various times probably land or sea. They all show that, in the past, what is now the area of the North American platform was more or less broken up into islands, large and small, and that there were very persistent and wide channels connecting the warm oceans with the Arctic Sea. According to Martonne[2] there was a channel connecting the Arctic Sea and the southern seas which passed over the area now occupied by the Ural Mountains, and which remained open during the whole of the Secondary and late Primary Eras. As far as the Northern Hemisphere is concerned it seems pretty clear that for long ages the openings from the south into the Arctic Sea were large and more numerous than they are now. At present our knowledge of the Southern Hemisphere conditions is less complete than is that concerning the Northern Hemisphere; but the flora and fauna of the Antarctic Continental rocks show that a large portion of them must have been below the sea-level at times, and that the climate must have been temperate. Indeed, the whole of the evidence we have points to the conclusion that in late Tertiary and post-Tertiary times the continental platforms became more land-covered than they had hitherto been; i.e. archipelagic conditions gave place in recent times to continental conditions.

Such an arrangement of the early land areas would of itself lead to warmer conditions in high latitudes, and this would reduce the strength of the temperature gradient in the troposphere. The stratosphere temperature gradient would then meet with less

[1] *Journal of Geology*, vol. xvii, 1909.
[2] *Traité de Géographie Physique*, 2nd ed., p. 595.

opposition, and the winds blowing towards the Poles would be increased in strength and produce a still further rise of temperature on the earth's surface in high latitudes.

The change from the archipelagic to continental conditions occurred about the time when, for some reason or other, the whole of the troposphere, and probably the stratosphere as well, became colder and the snow-line was lowered. Glaciers, consequently, formed on high mountain ranges and in high latitudes when the snowfall was sufficient. With the passing away of the conditions which gave rise to the Ice Age, glacial conditions disappeared almost entirely from all except high mountain ranges of middle latitudes; but owing to the joining up of the islands on the continental platforms frigid conditions remained over the Polar areas.

The whole subject of the climatic conditions through which the earth has passed is full of interest and difficulty. I have no wish to appear dogmatic on the subject, for much will have to be learned before any theory can be considered as probably correct. One thing seems to be pretty clear, and that is that until a sound theoretical reason can be given to account for the general winds of the earth blowing as they do there is little chance of dealing satisfactorily with the climatic changes which might result from geographical changes.

VI.—The Crawfordjohn Essexite and Associated Rocks.

By Alexander Scott, M.A., B.Sc.

Introduction.

ALTHOUGH the so-called Crawfordjohn essexite has been mentioned several times in petrographic literature, no detailed description of the occurrence has been given.[1] In 1888 Teall[2] described the main rock of the intrusion as an abnormal variety of the N.W.–S.E. Kainozoic dykes and noted the porphyritic augite and the abundance of felspar, olivine, and apatite. Lacroix,[3] in a general paper on the teschenites, mentioned the occurrence of nephelite in the same rock, which he described as an "olivine-teschenite, passing in structure to a tephrite". Bailey, in the Glasgow memoir,[4] remarked on the close similarity between the Crawfordjohn and Lennoxtown rocks and classed them with the essexites on account of their chemical similarity to the Brandberget rocks,[5] while Tyrrell,[6] on account of this similarity and also of the resemblance to the Carclout essexite, included them in the late Palæozoic alkaline group.

The intrusion occurs on the west side of Craighead Hill,[7] about one mile west of Abington Station and 2½ miles east of Crawfordjohn.

[1] No mention of it is made in the Explanation of Sheet 15 (Mem. Geol. Surv. Scotland), 1871.

[2] *British Petrography*, 1888, p. 197.

[3] *Compt. Rend.*, cxxx, p. 1273, 1900.

[4] *Geology of Glasgow District* (Mem. Geol. Surv.), 1911, pp. 113, 130.

[5] W. C. Brögger, Quart. Journ. Geol. Soc., l, pp. 15–38, 1894.

[6] Geol. Mag. [5], IX, p. 121, 1912.

[7] The Craighead Hill, mentioned in *The Silurian Rocks of Britain* (Mem. Geol. Surv.), i, 1899, pp. 462–3, 501, lies in the Girvan Valley, Ayrshire.

The chief exposures are in Craighead Quarry, on the 1,000 ft. contour-line, and in a disused quarry 200 yards to the south-east. A number of isolated exposures are found further up on the hillside. The general trend of the exposures is a line running N.W. and S.E., which is apparently parallel to the northern contact with the sediments. The main rock is well exposed in both quarries, as is a fine-grained marginal facies, but although sediments are also seen the actual contact is usually obscured by drift or debris. The sediments, which are of Ordovician age, consist mainly of grits and shales, folded and lying almost vertical, and have undergone considerable metamorphism by the intrusion. The southern contact is nowhere exposed, but the grits occur in situ, in a small drift-covered quarry, 200 yards south of the large quarry. The main mass of the intrusion is a grey compact rock showing numerous phenocrysts of augite. In places, the porphyritic aspect is not so pronounced, and the rock is apparently more even-grained. As the edge of the intrusion is approached, the grain-size diminishes until at the margin the rock is thoroughly aphanitic, none of the minerals being distinguishable in the hand-specimen.

The Essexites.

Microscopically, the porphyritic rock is seen to consist of numerous crystals of olivine and euhedral lath-shaped felspars, accompanied by, and occasionally included in, large phenocrysts of augite. Ilmenite and apatite are fairly abundant, and sporadic flakes of biotite also occur. The interstices are filled with nephelite and analcite.

The olivine occurs in the usual rounded crystals and, as noted by Teall,[1] is generally fresh and distinctly greenish in colour. The crystals are often enclosed by the augite and are euhedral towards the felspar. They contain a number of minute inclusions of a greenish-brown colour. These have no cleavage, are distinctly pleochroic, the colour varying from greenish-yellow to light-brown, and have a maximum extinction of about 35°. The refractive index is high, and the double refraction fairly strong. These characteristics agree with those of orthite, and the presumption that the inclusions are composed of this mineral is strengthened by the appearance of a reddish alteration product and by the fact that a trace of cerium oxide (and possibly thoria as well) was detected during the chemical analysis of the rock. In some of the more altered rocks, the olivine is replaced by pseudomorphs which closely resemble those in the Derbyshire Toadstones described by Bemrose.[2] The alteration commences along the cracks, and the pseudomorphs, which have a good cleavage, appear to have the same optical orientation as the original crystals. The pleochroism is very intense, and the colour varies from a blue-green (when the light is vibrating parallel to the cleavage-trace) to a deep red. The refractive index lies between that of olivine and felspar, the double refraction is fairly high and the axial angle apparently large. Although similar pseudomorphs have been

[1] *British Petrography*, 1888, p. 197.
[2] H. H. Bemrose, Quart. Journ. Geol. Soc., l, pp. 603–42, 1894.

described from a number of localities,[1] in no case has the exact nature of the mineral been determined. It has generally been described as a mica or chlorite-like mineral. The optical properties resemble those of pennine, but the pleochroism is too intense and the double refraction too high for that mineral. The green colour of the olivine indicates a high content of fayalite, and it is probable that the pseudomorph is some type of iron-rich chlorite.

The olivine-crystals are often surrounded by an irregular border of strongly pleochroic mica, while sporadic flakes of the latter also occur throughout the groundmass. The mineral seems to have arisen through the resorption of the olivine by the water-rich residual magma which finally crystallized as analcite.

The augite occurs in large idiomorphic crystals, up to a centimetre in diameter, and has the purple colour characteristic of the so-called titanaugite of alkali-rich rocks. The crystals are often twinned on *a* (100), and irregular intergrowths and crystal-groups commonly occur. There are numerous inclusions of olivine, labradorite, apatite, and orthite (?), these being sometimes arranged parallel to the boundaries of the augite. Morphologically and optically, the mineral resembles the augite of the Bail Hill tuffs,[2] the hour-glass structure being very marked and a strongly-developed zonary banding being visible even in ordinary light. As determined in a number of twinned crystals, the extinction in the 'b-sector' of the hour-glass is 40° and in the 's-sector' 42½°. The mean refractive index is about 1·70 and the double refraction ·030, the optic axial angle, as determined by means of the Federov stage, being 57½°. The dispersion of the bisectrices is fairly high, so that sections in or near the symmetry-plane do not extinguish in white light. The pleochroism is relatively strong, the scheme being a and c yellowish-brown, b reddish-purple (madder).

Some of the mineral was separated from the rock and analysed. This analysis, however, does not give the true composition of the mineral, as it is impossible to get rid of the numerous inclusions of olivine (sometimes occupying 20 per cent by volume of the augite). Column 6, table ii, gives the figures of the analysis made. It is certain that the ratio of lime to magnesia is too low on account of the amount of olivine present. The figures, however, could be used to determine the mode of the rock, as most of the inclusions are so small that they would be reckoned with the augite.

The plagioclase occurs as abundant lath-shaped crystals with the optical properties of 'basic' labradorite. These are sometimes sub-ophitically enclosed by the augite and occasionally even penetrate the olivine, but in general they are arranged in characteristic aggregates surrounding these two minerals. Occasionally much larger equi-dimensional crystals with well-developed zonal structure are found, and these appear to be of early formation. The orthoclase, which is

[1] H. W. Monckton, ibid., 1, pp. 40–1, 1894; H. H. Bemrose, loc. cit.; J. S. Flett in *Geology of East Fife* (Mem. Geol. Surv.), 1902, p. 392; R. B. Young, Trans. Edin. Geol. Soc., viii, p. 327, 1903; S. H. Reynolds, Quart. Journ. Geol. Soc., lxiv, p. 508, 1908.

[2] A. Scott, *Min. Mag.*, xvii, pp. 100–10, 1914.

not abundant, also occurs in squat crystals, though sometimes it appears to border the plagioclase. The nephelite is fairly fresh and seldom idiomorphic, being usually found in irregular aggregates. The analcite is always interstitial and very fresh, and is distinguishable by its high relief and absence of double refraction. There are also numerous small eumorphic prisms of apatite. The iron-ore is apparently a titanomagnetite, and is generally surrounded by a narrow rim of deep-brown biotite.[1]

The olivine is invariably the first mineral to crystallize after the accessory apatite and orthite (?) and the felspar the second, since they both occur enclosed in the augite. In some cases, the felspar has begun to solidify while the olivine crystals were still growing. The last-formed minerals are nephelite and analcite, the latter of which has not only filled the interspaces but has also, while still liquid, corroded the already formed phenocrysts with the production of biotite. The formation of the latter mineral is therefore to be ascribed to the action of the water-rich magmatic residuum on the already formed olivine and magnetite.

Although the porphyritic rock is fairly uniform, local differences in the relative amounts and grain-size of the various minerals are common. Column 1, table i, gives the mineralogical proportions, as determined by the Rosiwal method, of a rock from one of the exposures on the hillside, while column 2 gives those of a rock from the large quarry. The ratio of augite to olivine varies considerably, the variation being quite irregular so far as position in the intrusion is concerned. While one specimen from the large quarry is very poor in analcite and nephelite, the total amount of these minerals being about 3 per cent, others, within a short distance, contain as

TABLE I.

	1.	2.	3.	4.	5.
Plagioclase / Orthoclase	32·2	30·9	35·2	23·3	32·3
Nephelite	7·1	4·6	15·0[2]	12·6	6·1
Analcite	5·9	5·2		—	1·4
Titanaugite	27·4	41·0	34·5	36·1	25·9
Olivine	23·8	13·8	9·7	18·6	27·9
Biotite	·3	·4	1·5[3]	3·6	1·4
Ilmenite	2·3	2·9	3·7	4·2	4·3
Apatite	1·0	1·2	·4	1·6	·7
	100·0	100·0	100·0	100·0	100·0

1. Essexite (normal type), Craighead.
2. Essexite (augite-rich type), Craighead.
3. Essexite, Carclout, Patna.[4]
4. Theralite, Lugar.[5]
5. Kylite (less femic type), Craigmark.[6]

[1] Cf. R. Campbell & A. G. Stenhouse, Trans. Edin. Geol. Soc., ix, p. 126, 1907.

[2] Includes some turbid unidentified matter.

[3] Includes a little hornblende.

[4] Cf. G. W. Tyrrell, GEOL. MAG. [5], IX, p. 121, 1912. The writer is indebted to Mr. Tyrrell for the loan of slides of this rock.

[5] Ibid., p. 77.

[6] Ibid., p. 123.

much as 14 per cent. The distribution of the largest augites is also irregular, while it is curious that the very large crystals are often extraordinarily rich in inclusions. In the large quarry there are found several rocks which appear even-grained in the hand-specimen and some of which have pink felspar. In thin section, these are decidedly porphyritic, but the augite-phenocrysts are much smaller than in the rocks described above. The pink colour of the felspars is due to the fact that the latter are much 'analcitized',[1] being sometimes totally replaced by a dusty aggregate of analcite and other zeolites, although the interstitial analcite is often limpid and quite unaltered. In the neighbourhood of these rocks small clots, poor in ferromagnesian minerals but with abundant felspar and analcite, often occur.

TABLE II.

	1.	2.	3.	4.	5.	6.
SiO_2 .	44·37	45·03	43·65	43·10	40·87	43·94
TiO_2 .	2·37	2·30	4·00	2·80	2·85	4·38
Al_2O_3 .	14·19	14·82	11·48	13·94	16·23	7·01
Fe_2O_3 .	3·12	2·77	6·32	4·92	1·31	4·36
Fe O .	7·28	8·71	8·00	6·93	7·37	9·68
Mn O .	·24	·37	—	·14	·64	tr.
Mg O .	7·84	7·79	7·92	8·86	9·83	10·81
Ca O .	12·68	9·83	14·00	14·65	11·13	14·95
Na_2O .	3·86	4·33	2·28	2·50	2·78	3·76
K_2O . .	1·92	1·51	1·51	·89	·53	·57
H_2O + .	1·23	1·71	1·00	·55	1·35	·04
H_2O − .	·24	·24		·15	4·28	not found
P_2O_5 .	·83	·58	tr.	·27	·52	·41
CO_2 . .	not found	·22	—	·64	·38	not found
(Ba . Sr) O	tr.	—	—	·06	—	—
	100·17	100·21	100·16	100·40	100·07	99·91

1. Essexite, Craighead, analyst A. Scott.
2. Essexite, Lennoxtown, analyst W. Pollard.[2]
3. Essexite, Brandberget, analyst L. Schmelk.[3]
4. Essexite, Mt. Royal, Montreal, analyst B. J. Harrington.[4]
5. Theralite, Barshaw, analyst E. G. Radley.[5]
6. Augite (with inclusions), Craighead, analyst A. Scott.[6]

A sample of the fresh rock from one of the exposures on the hillside has been analysed and the results are given in column 1, table ii, several other analyses being included for comparison. The composition of the Craighead rock is very similar to that of the Lennoxtown essexite, and both resemble closely the Brandberget type. It was on account of this chemical resemblance that Bailey[7] classed the two former rocks as essexites. The name essexite was given

[1] Cf. J. S. Flett in *Geology of Edinburgh* (Mem. Geol. Surv.), 1910, p. 295.
[2] Summary of Progress of Geological Survey for 1907, 1908, p. 55; E. B. Bailey, loc. cit., p. 130.
[3] W. C. Brögger, loc. cit., p. 19.
[4] F. D. Adams, Geological Congress, Canada, 1913, Guide-book No. 3, p. 39.
[5] E. B. Bailey, loc. cit., p. 134.
[6] Another analysis of more impure material is given by G. W. Tyrrell, GEOL. MAG. [6], II, p. 363, 1915.
[7] Loc. cit.

by Sears[1] to an olivine-free soda-gabbro from Essex Co., Mass. Rosenbusch[2] expanded the term to include olivine-bearing types of the same rock, and also applied it to the Norwegian rocks which Brögger[3] had termed 'olivine-gabbro-diabase'. Owing to the fact that the amount of nephelite may vary widely, while olivine and hornblende may be absent or may be prominent constituents, the term essexite has been very loosely used, and rocks ranging from gabbro to theralite have been included in this class. The name should be restricted to those gabbroid rocks in which the felspar is strongly sodic and the nephelite small in amount. Where nephelite (or analcite) is a prominent constituent, the rocks should be classed as theralites, while the name essexite-theralite could be used for intermediate types. Where olivine or hornblende is present in notable amount, the terms 'olivine-essexite' and 'hornblende-essexite' could be used. Thus some of the specimens from Craighead could be included under the former name, while the latter could be applied to the dominant type in the Monteregian hills.[4]

That the Craighead rock is related chemically to the theralites may be seen by a comparison of columns 1 and 5, table ii, while the mineralogical connexion is evident from a consideration of columns 1 and 4, table i. This type, therefore, might be fitly termed an essexite-theralite, and the rock generally may be said to vary from a normal essexite to an olivine-essexite and essexite-theralite. Some of the olivine-rich varieties have obvious affinities with the less femic types of kylite (cf. column 5, table i), and it is apparent that by an increase in the amount of olivine a continuous sequence may be traced from essexite through olivine-essexite to kylite and finally kylite-picrite.

The Marginal Rocks.

Although several types of aphanitic rock can be recognized under the microscope, these generally exhibit a monchiquitic habit. One type, which occurs in the large quarry and may be distinguished in the hand-specimen by the 'spotted' appearance of the weathered surface, is rather less aphanitic than the others. In thin section it is seen to consist of abundant microphenocrysts of olivine and augite with scarcer felspar in a fine-grained matrix. The augite, though a titaniferous variety, is somewhat less pleochroic than the mineral of the essexites, while the olivine is usually replaced by an aggregate of fibrous serpentine. The ferromagnesian minerals are often poecilitically enclosed in the labradorite, a structure strikingly in contrast to that of the essexites, where augite is the enclosing mineral. The matrix consists of small granules of augite and magnetite in a dusty base of analcite and nephelite with locally a number of small felspar laths. Mineralogically the rock might be termed a nephelite or analcite basalt, but on account of its association

[1] Bull. Essex Inst., xxiii, p. 146, 1891.
[2] *Mikroskopische Physiographie*, 4th ed., 1908, II, i, p. 404.
[3] Loc. cit.
[4] F. D. Adams, loc. cit.; also *Journ. Geol.*, xi, pp. 239–82, 1903; J. A. Dresser, Geol. Surv. Canada, Mem. No. 7, pp. 14–18, 1910; J. J. O'Neill, ibid., Mem. No. 43, pp. 28–84, 1914, etc.

with the essexites and its intermediate texture, it may be included in the essexite-monchiquites. Lacroix[1] has applied this term to those monchiquites in which felspar predominates over nephelite and which have, in addition, an isotropic (presumably analcitic) groundmass. The Madagascar rocks differ from the one under consideration only in the presence of barkevikite and in a greater scarcity of olivine. The name is appropriate in the case of the Craighead rock, since, by an increase in the grain-size of the minerals, a gradual passage may be traced to a normal essexite.

Another 'spotted' rock represents a more felspathic and finer-grained type than the one described above. The phenocrysts are not so abundant, and the olivine rivals the augite in size. As before, both these minerals are poecilitically enclosed in felspar, which, however, also occurs as laths, of varying dimensions and often arranged in a radial fashion. The phenocrysts, together with a second generation of augite and numerous prisms of apatite, are enclosed in a matrix which is mainly analcite. In both of these rocks, local patches of a more acid nature occur. Olivine and porphyritic augite are absent, and the 'clots' consist of phenocrysts of labradorite in a groundmass of analcite, with subordinate nephelite and granular augite. These seem to be of late formation and to arise through the crystallization of a residual magma rich in water and alkalis.

(*To be concluded in our next Number.*)

VII.—On a New Genus and Species of the Thecidiinæ (Brachiopoda).

By J. Allan Thomson, M.A., D.Sc., F.G.S.

THE subfamilies Thecidiinæ, Dall, and Leptodinæ, Schuchert, constitute the family Thecidiidæ, Gray, which is regarded by Schuchert as a near relation of the Strophomenidæ. The chief external characters of the Thecidiinæ are the smallness of the shells, the absence of the foramen, attachment by the ventral valve, the presence of a nearly straight hinge-line and of a prominent area with a solid deltidium. The shell substance, with the exception of the deltidium, is punctate. Internally the ventral valve bears in its hollow beak a small median septum on which is sometimes superposed a small muscular plate. The dorsal valve bears a so-called cardinal process, formed by the median union of the socket ridges, and this plate is strong, subrectangular, and hollow at its base, and projects beyond the hinge. In most of the genera two lateral spurs unite mesially to form a bridge just in front of the cardinal process, over the visceral cavity. There are no free brachial arms, but the brachial supports are represented by an anterior septum, frequently branched, and lamellæ rising from the floor of the valve in the spaces between the septum and its branches, the margins, and the bridge. The septum runs back from the anterior margin towards the bridge, and like the margins and the bridge, is more or less covered with granulations.

[1] *Nouvelles Archives du Museum* [4], i, p. 142, 1903.

The subfamily appeared in the Devonian,[1] attained its maximum development in the Jurassic and Cretaceous, and is still represented by three living species. The genera are founded mainly on the form of the septum. This is simple in *Davidsonella* and *Thecidella*, bears two lateral branches in *Lacazella*, and four lateral branches in *Thecidea* and *Thecidiopsis*. In *Thecidiopsis*, *Eudesella*, and *Pterophloios* there are in addition a number of lateral septa.

As in the case of the Terebratulidæ and Rhynchonellidæ, the type genus *Thecidea*[2] is often used in a broad sense practically synonymous with the subfamily. All the recent and Tertiary species have been ascribed either to *Thecidea* (*sensu lato*) or to *Lacazella*. There is, however, as Hedley has recognized,[3] a stock quite distinct from *Lacazella* which has not yet been named, and for this I now propose:

THECIDELLINA, gen. nov.

Genotype *Thecidium Barretti*, Davidson.

Shell subtrigonal, attached by the back of the beak; surface smooth or with concentric growth-lines. Hinge-line broad and nearly straight. Ventral valve with a well-marked area, but apparently no deltidium.[4] In the hollow beak there is a small median septum from which two prongs project in front of the hinge-line. Interior of ventral valve granulose. Dorsal valve with the usual type of cardinal process and bridge. Median septum not branched, tapering behind to a sharp point. Brachial lamellæ attached to the end of the septum and curving forwards on each side parallel with the margin of the shell to near the front of the septum, when they are reflected back along the sides of the septum. The margin of the valve, the front of the septum, and the bridge are covered with granules.

Thecidellina differs from *Lacazella* in the presence of the prongs on the septum of the ventral valve instead of a muscular plate, and in the unbranched septum and simpler lamellæ of the dorsal valve. The dorsal valve is very similar to that of the Liassic *Thecidella*, in which, however, no bridge has been described and the septum is not acicular but broadly rounded. Moreover, a well-defined deltidium is present in this genus.

Thecidellina includes the recent tropical forms *T. Barretti*, Davidson (Jamaica) and *T. maxilla*, Hedley (Funafuti and New Hebrides) and a new species described below from the Tertiary (Oamaruian) of New Zealand. The discovery of the last adds additional weight to the argument that the Oamaruian of New Zealand enjoyed a warmer climate than the present, since the two recent species of the genus have a tropical distribution.

The only other Tertiary member of the Thecidiinæ so far found in the Southern Hemisphere is *Thecidium australe*, Tate,[5] from the Muddy Creek beds, Victoria. The interior of the dorsal valve of this

[1] Cf. Siemiradzki, Bull. Intern. Acad., 1909, p. 768 (*vide* Zool. Record).

[2] *Thecidium*, Sowerby, 1824, is a synonym of *Thecidea*, Defrance, 1822, and is still often erroneously used for *Thecidea*.

[3] Mem. Austral. Mus., No. 3, pt. viii, p. 510, 1899.

[4] Cf. Hedley, loc. cit.

[5] Trans. Roy. Soc. S. Austral., vol. iii, p. 116, pl. ix, figs. 3*a*–*c*, 1880.

species is unknown, but the presence within the umbo of the ventral valve of a "cup-shaped cavity divided longitudinally by a median septum" seems to connect it with *Lacazella*. All the Tertiary forms of Europe to the literature of which I have access belong also to *Lacazella*, viz. *L. Adamsi*, McDonald, from the Miocene of Malta, *L. testudinarium*, Michelotti, from the Miocene of Italy, and *L. latdorfiense*, Davidson, from the Oligocene of Germany, and the genus has also European Cretaceous representatives.

THECIDELLINA HEDLEYI, sp. nov.

Description.—Shell attached by the beak of the ventral valve, irregular in shape but in dorsal aspect rounded trigonal with a nearly straight front, greatest width near the anterior margin. Dorsal valve nearly flat, irregularly waved, raised near the umbo. Ventral valve strongly convex, oyster-like; commissures practically plane.

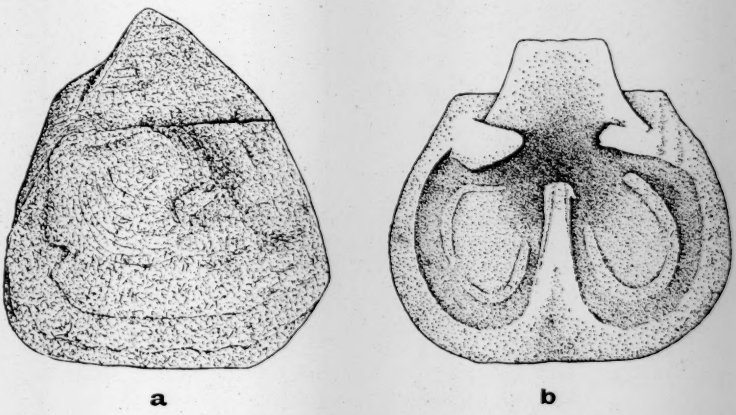

FIG. 1.—*Thecidellina hedleyi*, Thomson, Kakanui, New Zealand (enlarged 10 diameters). (*a*) Holotype, dorsal view; (*b*) paratype, interior of dorsal valve, ventral view.

Hinge-line straight, moderately broad, beak sharp, without foramen, area triangular, flat. Interior of dorsal valve: socket ridges converging slightly posteriorly and uniting mesially to form a process which is subrectangular and projects posteriorly considerably beyond the hinge-line, and is concave anteriorly. In front of the socket ridges there are two spurs pointing laterally inwards, probably the remains of a broken bridge. The margin is granulated, and is produced into a median septum, low anteriorly, rising posteriorly, and reaching a little beyond the middle of the shell. From this septum two lamellæ probably curved laterally forwards on each side, but are now disconnected in the specimen available. The granulations do not continue from the margin to the septum. Interior of ventral valve unknown.

Dimensions in millimetres:

	Length.	Breadth.	Thickness.
Holotype . . .	2·7	2·5	1·2
Paratypes . . .	2·8	2·0	1·5
	2·6	2·1	1·2

Type Locality.—Everett's limestone quarry, Kakanui, New Zealand.

Horizon.—Oamaruian (probably Miocene).

Material.—Holotype and four paratypes; one of the latter consists of a dorsal valve only.

Remarks.—The Kakanui limestone consists largely of hollow or partially filled shells of Brachiopods, a peculiarity of fossilization being that the pores of the shells are obscured, so that in many undoubtedly punctate shells, such as *Terebratula oamarutica*, Boehm, the punctation cannot be distinguished even under a microscope. The specimens of *Thecidellina hedleyi* are of a dull white colour and show no sign of punctation, but it does not necessarily follow that it is absent. No trace of deltidium can be seen, and this is in agreement with *T. maxilla*, Hedley. In external form *T. hedleyi* has more resemblance to *T. Barretti* than to *T. maxilla*, but is more nearly trigonal than either of these species.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science, Eighty-fifth Annual Meeting, held at Manchester, September 7–11, 1915. List of Authors and Titles of Papers read in Section C (Geology).

Presidential Address by *Professor Grenville A. J. Cole, F.G.S.*

Dr. G. Hickling.— Address on the Geology of Manchester and District.

Professor E. J. Garwood, F.R.S.—On the discovery of *Solenopora* and *Sphærocodium* in Silurian Rocks of Britain.

Hon. Professor W. Boyd Dawkins, F.R.S.—The Classification of the Tertiary Strata by means of the Eutherian Mammals.

Hon. Professor W. Boyd Dawkins, F.R.S.—The Geological Evidence of the Antiquity of Man in Britain.

Joint Discussion with Section E on the Classification of Land Forms. Opened by *Dr. J. D. Falconer.*

Canon T. G. Bonney, F.R.S.—Notes on the North-West Region of Charnwood Forest.

Professor W. W. Watts, F.R.S.—Note on Granite Surfaces of Mount Sorrel.

Dr. A. H. Cox & Mr. A. K. Wells.—The Ordovician Sequence in the Cader Idris District (Merioneth).

Professor W. G. Fearnsides.—A Contour Map of the Barnsley Seam of Coal in Yorkshire.

Mr. E. S. Cobbold.—Sixth Report on Excavations among the Cambrian Rocks of Comley, Shropshire.

Professor W. J. Sollas, F.R.S.—On the Restoration of certain Fossils by Serial Sections.

Dr. D. M. S. Watson.—Vertebrate Life Zones in the Permo-Trias.
Professor R. C. Wallace.—The Corrosive Action of Brines in Manitoba.
Dr. A. Wilmore.—Carboniferous Limestone Zones of North-East Lancashire.
Mr. H. Day.—A brief Criticism of the Fauna of the Limestone Beds at Freak Cliff and Peakshill, Castleton.
Dr. Arthur Vaughan.—On the Shift of the Western Shore-line in England and Wales during the Avonian Period.
Dr. Albert Jowett.—A Preliminary Note on the Glacial Geology of the Western Slopes of the Southern Pennines.
Reports of Research Committees.
Discussion on Radio-active Problems in Geology. Opened by *Professor Sir E. Rutherford.*
Professor C. A. Edwards.—Twinning in Metallic Crystals.
Dr. J. W. Evans.—The Isolation of the Directions Image of a Mineral in a Rock-slice.
Dr. G. Hickling.—On the Micro-structure of Coal.
Mr. Thomas Crook.—On the Economic Mineral Products of Damaraland, South-West Africa.
Mr. W. Lower Carter—Committee to consider the preparation of a List of Characteristic Fossils.
Professor E. W. Skeats.—Committee to consider the Nomenclature of the Carboniferous, Permo-Carboniferous, and Permian Rocks of the Southern Hemisphere.
Dr. F. A. Bather.—Committee to consider the preparation of a List of Stratigraphical Names used in the British Isles, in connexion with the Lexicon of Stratigraphical Names in course of preparation by the International Geological Congress.
Professor W. G. Fearnsides.—Committee to excavate Critical Sections in Lower Palæozoic Rocks of England and Wales.
Professor Grenville A. J. Cole.—Committee to investigate the Old Red Sandstone Rocks of Kiltorcan, Ireland.

SECTION E.—GEOGRAPHY.

Presidential Address by *Major H. G. Lyons, F.R.S.*
Professor J. W. Gregory, F.R.S.—Relations of the Central Lakes of Westralia.

II.—*Papers read before Section C (Geology), British Association, Manchester, September, 1915.*

(1) ON THE UNDERGROUND CONTOURS OF THE BARNSLEY SEAM OF COAL IN THE YORKSHIRE COALFIELD.

By W. G. FEARNSIDES, M.A., F.G.S., Sorby Professor of Geology, University of Sheffield.

IN this paper the author presents a preliminary account of the results of his statistical analysis of about a hundred records of borings and sinkings which have proved the depth of the Barnsley Bed or its equivalents (the Gawthorpe, the Warren House Coals of Yorkshire, and the Top Hard Coal of Derbyshire) in Yorkshire. The majority of the records of borings and sinkings discussed have

been collected by a committee of the Midland Institute of Mining, Civil, and Mechanical Engineers, and were published by that institution in volume form in 1914, the sites at which the information was obtained being plotted on a half-inch map. The depths to the coal have been corrected for the height of the surface location above sea-level, and, after the manner of Dr. Gibson's map (plate i) in the Geological Survey Memoir on the Concealed Coalfield (1913), contour-lines have been drawn among the spot-levels so obtained. Other contour-lines similarly obtained from the records of borings which have passed through Permian strata show the character of the surface of the Coal-measures where they underlie the Permian strata.

In drawing the contour-lines no attempt has been made to distinguish between those changes of level in the seam between neighbouring pits which are due to faulting, and those due to the folding of the strata. Since, however, over most of the coalfield the faults tend to nullify the change of level which the dip has accomplished, it is maintained by the author that to plot contours which show the average rate of change of level is a statistical method which yields a useful presentation of the truth.

1. From an analysis of the results as plotted it appears that the underground contours of the Barnsley Bed (strike lines) in Yorkshire in detail generally range either N.E.–S.W. or N.W.–S.E., and that within the area under which the Barnsley Bed has actually been proved by working it is difficult to find either a N.–S. or an E.–W. strike constant over more than a very few miles of country. This circumstance, if general over the coalfield, would seem to demand some revision of current views respecting the origin and structure of the Pennine Chain.[1]

2. The greatest structural division of the coalfield 'basin' is by the equivalent of a N.E.–S.W. anticline of which the southern limb is along the line of the Don faults from Sheffield by Rotherham and Conisborough to Doncaster. North of this line there is some evidence for the existence of a completed syncline, with its axis central near Frickley. In ground from which the Permian rocks have been denuded, the Barnsley coal attains a depth exceeding 1,800 feet below sea-level. The general line of this northern trough follows a N.W.–S.E. trend from Wakefield to South Kirkby, whence, displaced perhaps by the Don anticline, it bends somewhat eastward through Bulcroft. South of the Don a wider trough, also trending N.W.–S.E. through Yorkshire Main Colliery (Edlington) and Bawtry, carries the Barnsley Bed (at Rossington) below 2,600 feet.

3. The inclination of the Barnsley Bed is at its steepest near the outcrop, and after the manner of gentle folds the measures flatten

[1] These views were admirably expressed by Professor E. Hull, who in advocating them in 1868 succinctly remarked (Q.J.G.S., 1869, p. 331): "Immediately upon the close of the Carboniferous period the northern limits of the Yorkshire and Lancashire Coalfields were determined by the upheaval and denudation of the beds along east and west lines, while the coalfields themselves remained in their original continuity across the region now formed of the Pennine hills from Skipton southwards, and that at the close of the Permian period these coalfields were dissevered by the uprising of the area now formed of the Pennine range by lines of upheaval ranging from north to south."

out when the centre line of the syncline is approached. There is no evidence to suggest any general eastward rise of the Barnsley Seam within the area plotted on the map. (The eastern boundary of the map is through Thorne and Retford.)

4. By the plotting of the contour-lines on Bartholomew's layer-coloured half-inch contour map, the interdependence of underground structure and topographical relief in the area of the exposed coalfield has been well brought out. Over the whole coalfield most of the ridges are of escarpment form and are elongate along the line of strike, but from the map it becomes evident that wherever the strike of the Barnsley Bed shows a change of direction, there the escarpment ridges are found upstanding above their average height, and this whether they form the arches or lie in the troughs of the folds.

From his experience of the application of the contour method to the study of the tectonics of the Barnsley Bed, the author suggests that the method is of peculiar usefulness in coalfield work. He offers this preliminary account of the results of his work in Yorkshire in the hope that workers on the western side of the Pennines may take up the method and use it in the further investigation of the many and difficult problems of geological structure presented by the 'Backbone of England'.

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(2) A Brief Criticism of the Fauna of the Limestone Beds at Treak Cliff and Peakshill, Castleton, Derbyshire. By Henry Day, M.Sc.

THE author put forward some observations on a collection of some three hundred species of Carboniferous Limestone fossils from the localities Treak Cliff and Peakshill, Castleton, and embracing about one hundred species of Brachiopods and Corals. The beds at both places may be referred to the 'Brachiopod beds' of Sibly (Q.J.G.S. 1908), which are allocated by him to sub-zone D_2—the Lonsdalia sub-zone. The present list of species presents some features of considerable interest bearing on the value of certain types as zonal indices. Reference is made to Vaughan's paper on the Bristol area, where it is indicated that amongst the Brachiopod groups confined to the Tournaisian in that area are the following: *Productus* cf. *Martini*, *Leptena analoga*, *Schizophoria resupinata*, *Rhipidomella* aff. *Michelini*, *Spiriferina octoplicata*, *Syringothyris cuspidata*. Two of these, it is noted, *Spiriferina octoplicata* and *Schizophoria resupinata*, are sub-zonal indices, and each with its maximum in its sub-zone. The list of Castleton forms from well up in D, now presented, includes all the above-mentioned Brachiopod groups. *Syringothyris cuspidata* and *Spiriferina octoplicata* are fairly abundant at both Treak Cliff and Peakshill, *Schizophoria resupinata* is extremely abundant at both places, *Leptena analoga* is abundant, whilst *Productus* cf. *Martini* and *Rhipidomella Michelini* are rare.

Passing to the coral fauna, the genus *Zaphrentis* appears in the Castleton list, i.e. one of the two genera of Corals confined to the Tournaisian in the Bristol area and not extending into the Viséan. The genus, though not very abundant, is represented by several species. In addition, the genera *Michelinia* and *Amplexus*,

characteristic of the Upper Tournaisian of Bristol, but possibly extending into the base of the Viséan, are cited in the Castleton list, *Michelinia glomerata* being fairly abundant at Peakshill, and *Amplexus coralloides* is found at Treak Cliff, but is extremely rare.

These facts lead to a consideration as to how far the types mentioned are of value in zonal determinations. If any one of them, as recorded from Castleton, be regarded as representing exactly the same form as that recorded from the Bristol area, then its value as one of a number of index fossils of a zone becomes negligible. Examples are cited in the cases of *Spiriferina octoplicata* and *Schizophoria resupinata*. If the Castleton forms of D_2 horizon agree in identity with the Bristol types of K_2 and Z_2 respectively, then these two types become worthless as sub-zonal indices. It was pointed out that, even allowing of the rather unlikely possibility that in all the cases cited the Castleton specimens represented mutational forms of the Bristol species, the real difficulty as to their zonal value is not overcome, since the line of demarcation between mutations is more or less arbitrary, and there is still a considerable field of discussion as to what constitutes a 'mutation'.

It appears probable that any system of zonal indices can be of local value only, as for example in the application of the Bristol zonal indices within the Bristol area, and cannot be of any general application.

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(3) A Preliminary Note on the Glacial Geology of the Western Slopes of the Southern Pennines. By Albert Jowett, D.Sc., F.G.S.

THE area dealt with extends from Blackstone Edge southwards to the southern extremity of the Pennines.

No striated surfaces of solid rock have been discovered at high levels, and the two that have been recorded at Salford and Fallowfield serve only to indicate a general movement from N.W. to S.E. For more detailed information as to the movements of the ice-sheet, the only evidence is that afforded by the distribution of the drift at high levels and by the systems of drainage along the edge of the ice. From this it may be inferred that the main directions of ice movement about the time of the maximum extension of the ice-sheet were roughly towards the north-east in the Tame Valley, the east in the Etherow Valley, and the south-east and south-south-east in the Goyt Valley and further south. These directions were much modified locally by the complicated configuration of the sub-glacial surface.

The first barrier of hills met with on approaching the Pennines from the South Lancashire and Cheshire plain was almost everywhere overridden by ice, which left definite deposits of drift with foreign rocks at altitudes up to 1,360 feet, and scattered erratic boulders up to 1,400 feet. As this foreign drift penetrates further into the hills its maximum altitude falls steadily. It has only been traced across the main Pennine divide at the broad col (1,100 feet above O.D.) south-east of Chapel-en-le-Frith.

Thick deposits of drift and big erratics are comparatively rarely met with at the extreme limit of the foreign drift, towards which

the erratics generally diminish in number and in size. Boulders of local rocks, often obviously transported and uplifted beyond their parent outcrops, become relatively more abundant towards the limit of the foreign drift, and generally form a spread of drift extending beyond it and passing insensibly into the driftless area.

Great lakes were held up by the ice barrier some time after it commenced to retreat from the western slopes of the Pennines. During early stages in this retreat the drainage from the lakes in and north of the Etherow Valley escaped northwards, and ultimately passed through the Walsden Gap into the Calder. When the ice barrier east of Manchester fell below 600 feet above O.D., this drainage followed the course of that south of the Etherow Valley and escaped southwards.

The action of the ice-sheet with its associated streams of water, together with the marginal water derived from melting ice and draining from the region beyond the ice-sheet, assisted by the action of post-glacial streams, in depositing the original drift, in cutting new channels through rock and drift, and in resorting and redepositing the debris, seems quite sufficient to account for the complicated superficial deposits in this area.

No evidence has been found of more than one period of glaciation nor of any local glacier system. There are, however, curious corrie- or cirque-like features, e.g. on Shelf Moor, Glossop. Moreover, although the Pennines are on the whole much lower north of the Etherow Basin than further south, the overflow channels of glacier lakes can be found at higher altitudes in the former than in the latter region. This is the reverse of what might be expected if the higher ground were ice-free. It may be, therefore, that at and near the time when the ice-sheet attained its maximum development the snow-line actually descended below the altitude of the higher Pennine hills, and, without bringing about a definite local glaciation, temporarily filled the higher hollows with snow up to the general level of the ridge. Thus, instead of the margin of the ice-sheet at that stage melting away rapidly, melting might be considerably reduced and even temporarily suspended, and the ice-sheet reinforced by the local snowfall. Such conditions would tend to depress the limit of distribution of erratics immediately west of the highest ground, but where an ice-stream carrying erratics actually crossed the watershed they might lead to the distribution of those erratics further and more widely than otherwise might have been possible.

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(4) The Old Red Sandstone Rocks of Kiltorcan, Ireland. Report of the Committee, consisting of Professor Grenville Cole (Chairman), Professor T. Johnson (Secretary), Dr. J. W. Evans, Dr. R. Kidston, and Dr. A. Smith Woodward.

THE Committee has spent the sum of £5 from the unexpended balance of the grant made in 1913, and has returned the remaining balance to the General Treasurer. The grant of £10 made in 1914 was not called on, since the work for which it was

specially intended, excavation at Tallow Bridge, proved impracticable, owing to local difficulties. The regular working of the Kiltorcan quarry, however, makes it desirable to secure good specimens as they are turned out, since the owner is the local contractor for roads, and the stone and plant-remains become alike used in making the Kilkenny highways. Short of actual purchase and preservation of the historic site, the alternative is to pay the owner to watch the work as it goes on and to set aside the more interesting material. He has shown a ready appreciation of the requirements of the Committee.

Hence the Committee asks for its continuance and a grant of £10 for the excavation work at Kiltorcan, and for specimens obtainable in 1915–16.

The Committee would be glad to be allowed to send, carriage forward, duplicate material of *Archæopteris*, *Bothrodendron*, *Archanodon*, etc., to the botanical and geological sections of universities, colleges, and museums in the British Empire, where it is found that such specimens would be welcome. Such gifts would, of course, be accompanied by a statement as to the auspices under which the material was obtained.

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(5) The Geological Evidence in Britain as to the Antiquity of Man. By Hon. Professor W. Boyd Dawkins, M.A., D.Sc., F.R.S.

PROFESSOR BOULE, in his masterly essay published in *Anthropologie*, xxvi, Jan.-Avril, 1915, freely criticized the evidence on which the antiquity of man in Britain has been stated to go back beyond the early Pliocene age, and concludes that it is not of a nature to throw light on so important a problem. The antiquity of man—or, in other words, his place in the geological record—is a geological question to be decided, like all others, on the lines of a rigid induction. In each case it is necessary to prove, not only that the objects are of human origin, but further that they are of the same age as the strata in which they occur, without the possibility of their having been introduced at a later time. In this communication I propose to apply these tests to the evidence.

The Pliocene age of man in East Anglia is founded entirely on the roughly chipped flints in the basal Pliocene strata—on eoliths, mainly of the rostro-carinate or eagle's-beak type of Moir and Lankester. It has been amply proved in this country by Warren, Haward, and Sollas, and in France by Boule, Breuil, and Cartailhac, that these can be made without the intervention of man by the pressure and movement of the surface deposits, by the action of ice, by the torrents and rivers, and by the dash of the waves on the shore. The type-specimens taken to be of human work have been selected out of a large series of broken flints that graduate into forms obviously made by natural fractures. They are, as Boule aptly says, "hypersélectionnées," and can only be rightly interpreted by their relation to the other flints on the Pliocene shore-line.

As might be expected, if they are due to natural causes, the 'rostro-carinates' are widely distributed through the basal beds of the Crag

in Norfolk and Suffolk. They occur also in the Upper Miocenes of Puy-Courny (Auvergne), in the Pleistocene gravels of London, and the present shore-line of Selsey, where they are now probably being made by the breakers. For these reasons I agree with M. Boule that they have not been proved to have been made by man, and that therefore they throw no light on his place in the geological record.

The presence of man in East Anglia during the Glacial period is founded on even worse evidence than this. The Ipswich skeleton on which Moir and Keith base their speculations was obtained from a shallow pit sunk through the surface soil of decalcified boulder-clay—not of boulder-clay in situ, as stated—into the Glacial sand that crops out on the valley slope. It is, in my opinion, a case of interment that may be of any age from the neolithic to modern times. The skeleton also is of modern type, and belongs, as Duckworth shows, to the graveyard series of burials.

We come now to the consideration of the evidence of the famous discovery on Piltdown of *Eoanthropus Dawsoni*—the missing link between primitive man and the higher apes. After the examination of the whole group of remains, and a study of the section, I fully accept Dr. Smith Woodward's opinion that the find belongs to the early Pleistocene period. The associated implements are of the same Chellean or Acheulean type as those so abundant in the mid-Pleistocene Brick-earths of the Thames Valley between Crayford and Gravesend. They may imply that *Eoanthropus* belongs to that horizon, in which the stag is present and the reindeer absent. It must not, however, be forgotten that the classificatory value of these implements is lessened by their wide range in Britain and the Continent through the later Pleistocene River deposits. The stag, the beaver, and the horse of Piltdown—leaving out of account the Pliocene fossil mammals more or less worn into pebbles—are common both to the pre-Glacial Forest-bed and the Lower Brick-earths of the Thames Valley and the later Pleistocene River-deposits. It must also be noted that the intermediate characters of the Piltdown skull and lower jaw point rather to the Pliocene than the Pleistocene stage of evolution. We must, in my opinion, wait for further evidence before the exact horizon can be ascertained. On the Continent there is no such difficulty.

The earliest traces of man are there represented at Mauer by a mandible associated with the peculiar fauna of the Forest-bed, showing that *Homo Heidelbergensis*, a chinless man, was living in the Rhine Valley during the earliest stage of the Pleistocene. The Neanderthal man, thick-skulled and large-brained, with small chin and stooping gait, belongs to the Mousterian stage, that, in my opinion, is not clearly defined from the Chellean and Acheulian gravels of the late Pleistocene. He ranged from the Rhine through France southwards as far as Gibraltar, and was probably the maker of the Palæolithic implements of those strata throughout this region. It is also probable that he visited Britain, then part of the Continent, in following the migration of the mammalia northward and westwards across the valley of the English Channel. While primitive men of these types inhabited Europe there was no place in the Pleistocene

fauna for the thin-skulled men taken by Dr. Keith[1] and others to prove that modern types of men lived in Britain in the Pleistocene age.

Man appears in Britain and the Continent at the period when he might be expected to appear, from the study of the evolution of the Tertiary Mammalia—at the beginning of the Pleistocene age when the existing Eutherian mammalian species were abundant. He may be looked for in the Pliocene when the existing species were few. In the older strata—Miocene, Oligocene, Eocene—he can only be represented by an ancestry of intermediate forms.

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(6) The Classification of Land Forms. By Dr. J. D. Falconer, M.A.

THE investigation of processes is the common ground of geology and geography. The geographical processes, however, are less numerous than the geological and are studied by geologists and geographers with a different purpose. The geologist studies these processes in order to elucidate the past history of the earth, the geographer in order to systematize the present topographical features of the surface. Geological interest in the geographical processes thus ceases as soon as the so-called land forms have been referred to their respective processes or combinations of processes. Since most textbooks of physical geography have been written from the geological point of view, it follows naturally that the treatment of land forms in these textbooks is entirely subsidiary to the discussion of processes and offers no clue to the scientific definition and classification of individual forms. It is believed, however, that these submit themselves to systematic classification with almost as much ease as the subject-matter of other natural sciences, and that it falls clearly within the scope of geography as the science of the earth's surface to establish such a classification. The first attempt in this direction was made by Professor Passarge, of Hamburg, in 1912.[2] The classification outlined below is based upon similar principles and has already appeared in the *Scottish Geographical Magazine*.[3]

It is proposed to set up two classes of land forms, each containing two orders—

Class A. Endogenetic Forms.
  Order I. Negative Forms.
  Order II. Positive Forms.
Class B. Exogenetic Forms.
  Order I. Degradation Forms.
  Order II. Aggradation Forms.

The two orders of endogenetic forms are then subdivided into four families—

Family 1. Forms due to superficial volcanic activity.
2. ,, ,, sub-crustal volcanic activity.
3. ,, ,, radial movements.
4. ,, ,, tangential movements.

[1] The skeletons of Galley Hill, in Kent, and probably that of Cheddar cave in Somerset, have, in my opinion been buried, and do not belong to the Pleistocene age. They are either prehistoric or even historic.

[2] Mitt. der Geog. Gesell. in Hamburg, xxvi, p. 133, 1912.

[3] xxxi, p. 57, 1915.

Similarly, the two orders of exogenetic forms are each subdivided into nine families—

Family 1.	Forms due to the action of the run-off.			
2.	,,	,,	,,	percolating water.
3.	,,	,,	,,	streams and rivers.
4.	,,	,,	,,	life.
5.	,,	,,	,,	lightning.
6.	,,	,,	,,	sun heat.
7.	,,	,,	,,	the atmosphere.
8.	,,	,,	,,	frozen water.
9.	,,	,,	,,	the sea.

Each family is then subdivided into genera and species or specific forms. It is suggested that a land form be defined as any surface or slope which may be referred in origin to the operation of a single process or force. Monodynamic surfaces of this kind being rare, however, the commoner polydynamic surfaces may be classified according to the predominant force amongst those responsible for the production of the surface. This definition may be extended to include such surface features as cones or domes enclosed by one continuous surface, or such features as ridges or mounts enclosed by surfaces meeting in edges, provided that all these surfaces may be classified as examples of the same specific form.

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(7) The Isolation of the Directions Image of a Mineral in a Rock-slice. By J. W. Evans, D.Sc., LL.B.

THE author discussed the different methods by which the interference figures of a small mineral in a rock-slice may be kept distinct from those of adjoining minerals. He recommended two. In one, which he believes to be new, a diaphragm with a small aperture is placed below the condenser, which is lowered till the image of the aperture appears in focus on the rock-slice. In some microscopes the iris diaphragm provided for the Becke method of determining the refractive index may be employed. In others it is too near the condenser. The aperture should be sufficiently large to illuminate the maximum area of the mineral under investigation, but no portion of the others. The directions image may then be observed in any of the usual ways. Unless the condenser and diaphragm revolve with the stage the aperture must be very carefully centred with the axis of rotation.

The other method was proposed by Becke in 1895, but is very little known. The diaphragm is placed in the focus of the eye-piece so as to shut out all except the mineral selected. The Becke lens, or system of lenses resembling an eye-piece, is placed above the eye-piece, when the directions image of the mineral will be seen without any admixture of light from its neighbours. This method has the advantage that the diaphragm is less highly magnified at the time of adjustment. When a rotating stage is employed, a very accurate centreing of the nose-piece of the microscope is required, so that the coincidence of the object with the aperture may be maintained.

The common practice of placing a diaphragm for this purpose immediately below the Bertrand lens rests on no scientific basis, and is not effective in shutting out the light of minerals other than that which is being studied.

REVIEWS.

I.—Catalogue of the Mesozoic Plants in the British Museum (Natural History). The Cretaceous Flora: Part II. Lower Greensand (Aptian) Plants of Britain. By Marie C. Stopes, D.Sc., Ph.D. 8vo; pp. xxxvi + 360, with 112 text-figures and 32 plates. Trustees of British Museum. London: Dulau & Co., 37 Soho Square, W., 1915. Price 21*s*.

WE heartily congratulate the author of the volume, and the Department of Geology which is responsible for its publication, on the appearance of this second instalment of the Catalogue of the Cretaceous Flora. Dr. Stopes is well qualified for the task of investigating the often unpromising fragments upon the study of which a knowledge of this flora is based, and the book is a record of careful painstaking research. It appeals essentially to the botanist, who will examine with admiration the photographs, and more especially the line drawings, in which Dr. Stopes illustrates the histological structure of the species she is describing. In preservation of detail many of these Lower Greensand species are equal to the remarkable specimens with which we have become familiar in the Coal-measure petrifactions. As the author reminds us, the plants of the Lower Greensand in this country are found under very favourable conditions, occurring in a well-defined and well-known marine deposit. The principal localities are the coasts of the Isle of Wight, the quarries of North Kent near Maidstone and Ightham, near Woburn and Potton in Bedfordshire, and near Leighton Buzzard in Bucks. Forty-five forms are described, comprising one Thallophyte (*Chondrites Targionii*), two Ferns, nine Cycadophyta, twenty-seven Conifers, and five Angiosperms. As compared with other Mesozoic floras the list is remarkable for the scarcity of Ferns and the great preponderance of Conifers. In the Wealden flora, on the other hand, the Ferns head the list and the Conifers are relatively few, while Angiosperms are unrepresented. The Aptian flora is characterized by absence of leaf-structures, and is composed mainly of woody stems with a fair sprinkling of gymnospermic cones. These characters are explained by the nature of the deposits, which represent "a narrow arm of the sea in which a coarse marine detritus was being laid down at no great distance from land". The plant remains must have drifted for some time before they were entombed, and this resulted in the elimination of all the soft leaves. The only well-preserved leaf is that of a twig of *Sequoia* which had become sheltered in the stem of a larger plant. Hence the absence of herbaceous plants does not imply their non-existence in the flora, and, as the author points out, does not support the view that the woody tree is the primitive type of Angiosperm. The five genera of Angiosperms described are the earliest Dicotyledons recorded for the North of Europe, and the earliest specimens of which the anatomy is known from any part of the world, but Dr. Stopes wisely refrains from adding to the burden of the discussion of the origin of Angiosperms. The species studied "were woody plants of a highly advanced and differentiated character, and there is nothing in their anatomy to indicate any more clearly their phylogenetic origin than

there is in the stems of the still living genera". But she does not favour the *Bennettites* solution, and suggests that the existence of highly differentiated Angiosperms in the strata from which the typical *Bennettites Gibsonianus* and others were obtained adds to the improbability of a Bennettitalian ancestry for the Angiosperms.

As regards the climate of the Aptian period, the inference is drawn that it was relatively cool with well-marked seasons, thus contrasting with the more tropical climate of the preceding Wealden and succeeding Gault and Upper Greensand. The inference is based on the large number of Abietineæ and the absence of Araucarineæ among the Conifers, and the well-marked annual rings in the wood of the latter.

The account of the Coniferous woods is prefaced by a useful discussion of the histological characters which may be regarded as supplying trustworthy data for systematic determinations; and the writer condemns the use of various minute details which prove to be merely individual variations and to have no specific value.

As regards the plants enumerated, the two Ferns are previously described species of *Weichselia* and *Tempskya*; an interesting restoration of *T. rossica* is depicted, provided by Dr. Kidston and the late Professor Gwynne-Vaughan, whose untimely death leaves a serious gap in the ranks of workers on plant anatomy. Cycadophyta are represented by *Bennettites*, including a new species, *B. Allchini*; *Cycadeoidea*, also with a new species from the classic locality for *C. Yatesii*; a new genus *Colymbetes*, with a remarkable stem anatomy, perhaps from the same locality; and two doubtful specimens. The Coniferales include a *Sequoia*, very near to the living *S. gigantea*; new species of *Protopiceoxylon* and *Pityoxylon*; species of *Pinostrobus* and *Cedrostrobus*; new species of *Cedroxylon* and *Cupressinoxylon*, in addition to the previously described *Cupr. vectense*, Barber; new species of *Taxoxylon* and *Podocarpoxylon*; and a remarkable specimen known only from a mass of secondary tissue, the position of which is doubtful; it is described as *Vectia luccombensis*. The five dicotyledonous Angiosperms are founded on as many specimens, and correspond to no previously known genera. Dr. Stopes is unable to assign them to any existing family, but tentatively suggests that one, *Woburnia*, may be a Dipterocarp.

A. B. Rendle.

II.—Meteorites.

1. Victorian Meteorites. — In Memoir No. 6 of the National Museum, Melbourne (pp. 66, with 5 plates, April, 1915), Mr. R. Henry Walcott describes very fully the Victorian meteorites and adds some notes on obsidianites. The meteorites comprise the three Cranbourne, including the Yarra Yarra fragments, Beaconsfield, and Langwarrin meteorites, which are shown to be probably remains of one fall, and the Bendoc, Yarroweyah, and Kulnine meteorites. Their history and characters are in each case discussed in detail. The best known of them is the Cranbourne, of which No. 1, the largest, weighing about 3½ tons, is in the Natural History Museum, London, and No. 2,

weighing 30 cwt., is in the Melbourne Museum; No. 3 has disappeared. Unlike the larger mass, No. 2 appears to have exuded very little chloride of iron, and no scaling has been observed. The Bendoc and Yarroweyah irons are both in the Melbourne Museum; they weighed 60 lb. and 21 lb., and were discovered in 1898 and 1903 respectively. The Kulnine iron, which weighed 122 lb., and was found in 1886, is in the Adelaide Museum. A table of chemical analyses and a full bibliography are given. The author concludes that the obsidianites (australites), though glassy in character, are undoubtedly meteoric in origin.

2. Meteoric Irons from the Klondike Mining District, Yukon.—In the Museum Bulletin No. 15 of the Geological Survey of Canada (pp. 8, with 11 plates, June 30, 1915), Mr. R. A. A. Johnston describes the meteoric irons found in the course of gold-mining operations in Gay Gulch and Skookum Gulch, both tributary to the Bonanza Creek system in the Klondike mining district, Yukon. The former weighed 483 grams and was found in 1901. The latter, which was discovered on January 21, 1905, was much larger; it measured 29 cm. in length, 23 cm. in width, and 3 to 8 cm. in thickness, and weighed 15·88 kilograms. Both specimens were acquired by the Ottawa Museum. From the similarity in the characters of the two irons, both being exceptionally rich in nickel and exhibiting a peculiar chatoyancy in sections, and in their positions, both lying on the bedrock under the 'white channel' gravels, as the miners term the ancient creek deposits, the author considers that they are relics of a single meteoric shower, which occurred in Tertiary time.

CORRESPONDENCE.

COAST EROSION IN NORFOLK.

Sir,—On September 1 of this year I found the well-known tower of Sidestrand old Church, near Cromer, now on the very edge of the cliff: a rabbit could not pass between. It had begun to crack, and its fall may come at any time. On April 27, 1905, I made a rough map of churchyard, tower, and cliff-edge; and noted the distance between tower and cliff-edge as then 7 feet. I record this as a contribution towards estimates of cliff-waste on this coast.

In the Geological Magazine, 1895, pp. 229, 230, are calculations of rate of inland retreat for the sand-dunes at Eccles, 12 miles south-east. The calculations give a retreat of somewhere about 130 feet in seventy-seven years.

E. Hill.

The Rectory, Cockfield, Bury St. Edmunds.
September 15, 1915.

HUMAN PALÆONTOLOGY IN ENGLAND.

Sir,—The current number of *L'Anthropologie* (January–April, 1915), I notice, contains a paper by M. Boule entitled "La paléontologie humaine en Angleterre", which is the most extraordinarily biassed statement it has ever been my ill-fortune to read.

M. Boule in this paper refers especially to the flaked flints found beneath the Red Crag of Suffolk, and also to the human skeleton found by me in Messrs. Bolton & Laughlin's sand-pit at Ipswich in 1911, and in criticizing these discoveries has certainly lived up to the view expressed on p. 38 of his paper that it is better to be too severe in criticisms of such matters than not to be severe enough. In this note I propose to emulate M. Boule's 'severity', and to speak out plainly as he has done. But I do not intend to make any reply to the threadbare and foolish arguments he uses in support of his case, arguments which I have replied to a great number of times, and which I do not intend to discuss any further. I want, however, to say something about M. Boule's and his colleague M. Breuil's attitude towards the discoveries I have mentioned, and their capabilities of judging whether a flint has been flaked by nature or by man. Regarding the first, I am of the opinion that both M. Boule and M. Breuil are hopelessly biassed in favour of the view that the human race is not more ancient than the early Chellean period, and I hold this view for the following reasons. It has come to my knowledge from an unimpeachable source that many weeks before either of these gentlemen visited Suffolk or had seen a single one of my specimens, they had expressed their disbelief in the value of my discoveries. I also know, from personal observation, that when they were here they showed very plainly and unmistakably that they did not intend to examine carefully and scientifically the sub-Crag flints or the beds from which they were derived, nor did they spend more than a few minutes in examining the section in the pit where the Ipswich skeleton was found. Their attitude to all the things they saw was careless and almost petulant, and in my opinion quite unscientific. Regarding the capabilities of MM. Boule and Breuil of judging whether a flint has been flaked by nature or by man, I am of the opinion that neither of them is capable of such judgment, and I hold this opinion for the following reasons. After the sub-Crag flints had been seen and rejected as humanly fashioned I showed M. Boule a series of the Middle Glacial specimens, and without telling him from what stratum they were derived asked whether he regarded them as 'human' or 'natural'. He at once said he thought they were definite implements of man. I then told him where they were found, and immediately he disputed the correctness of the geological interpretation. When, however, I showed him that this interpretation was undoubtedly correct, he said that the flints could not be humanly fashioned. I notice at p. 13 of M. Boule's paper he describes these Middle Glacial specimens as "formes troublantes", and I can quite understand why he so regards them. On the morning of the second day of the visit of MM. Boule and Breuil I showed the latter a flint scraper found beneath the shelly Red Crag, which in form was identical with the scrapers which are found in nearly every period of the Stone Age, and asked him whether he considered it to be humanly fashioned or flaked by natural forces. He replied that it was his opinion that nature was responsible for the flaking. I then asked him to tell me what force he considered had flaked the flint, and he simply shrugged his shoulders and said he did not

know. Now regarding M. Boule's statement about the Middle Glacial flints it is evident that he does not know the difference between a humanly fashioned flint and one that has been flaked by nature, because he first of all stated these Middle Glacial specimens were 'human', and then when he was told the deposit from which they were derived he immediately said they were non-human. M. Breuil was equally illogical and childish in his remarks about the sub-Crag scraper, because after having stated dogmatically that the specimen was 'natural' he was quite unable to state what natural force had produced the flaking to be seen upon it. These are the facts of the case, and no references to the curious remarks of Professor Boyd Dawkins, or the worthless flints collected by Professor Sollas on the beach at Selsey Bill, will alter them. I have been loath, especially at the present time, to write what I have done, but in view of M. Boule's provocative paper, which many people, not knowing the facts, will regard as reliable, I feel I am justified in speaking out, and in so doing to aid the cause of science.

J. Reid Moir.

12 St. Edmund's Road, Ipswich.

STUDIES IN EDRIOASTEROIDEA. A CORRECTION.

Sir,—I deeply regret to find that a bothering error has crept into the lettering of Text-figure 1, on p. 260,[1] illustrating Studies in Edrioasteroidea, VII. In each of the drawings the rays have been numbered in the wrong order, so that what are now V, IV, III, II, I should read I, II, III, IV, V. The numbers in the text itself, as well as in the figures on p. 398 are correct. Possessors of the Geological Magazine can perhaps make the necessary alteration without much difficulty. It will be put right in the complete set of reprints. With more than the usual apologies.

F. A. Bather.

September 17, 1915.

OBITUARY.

WILLIAM ANDERSON, F.R.S.E., F.G.S., F.R.S.G.S.

Born February, 1860. Died May 30, 1915.

Mr. W. Anderson was the eldest son of Dr. Joseph Anderson, late Keeper of the National Museum of Antiquities and Assistant Secretary of the Society of Antiquities of Scotland, Edinburgh.

A vacancy having occurred on the staff of the Geological Survey of New South Wales, Mr. William Anderson was recommended by Sir Archibald Geikie to Mr. C. S. Wilkinson, the Government Geologist, to fill the gap as Field Geologist. At the time of his selection he was a student at the University of Edinburgh, but proceeded forthwith to Sydney and commenced his official duties in September, 1886. Mr. Anderson's life on the Geological Survey was a very busy one; he contributed many valuable reports on the geological and mineral resources of the Colony, which may be found in the "Annual Reports of the Department of Mines of New South

[1] Geol. Mag., June, 1915.

Wales, 1886–91". Before leaving Scotland Anderson had already commenced to publish the result of local observations, at least two papers being read before the Geological Society of Edinburgh in 1885–6.

In 1888 he explored the Yarrangobilly Caves, which have since become a well-known tourists' resort; he also examined the neighbouring Kiandra Goldfield. During 1887 he accompanied Mr. Wilkinson to the Bingara Diamond-field and Cope's Creek, and reported on the possibility of existing auriferous deposits in the Byrock, Nyngan, and Girilambone Districts, and the well-established metalliferous zone around Cobar.

Pleistocene deposits, rich in marsupial remains, were known to exist at Myall Creek, near Bingara, and in 1888 Mr. Anderson was sent to investigate these and superintend the excavation of the fossils; these are now in the Mining and Geological Museum, Sydney. He also, during the year, reported on the important discovery of fish in the Hawksbury Formation at Talbragar, Mudgee District; these have since been described by Dr. A. Smith Woodward. In 1889 a most important investigation was commenced by the Geological Survey in the delineation of the great Cretaceo-Tertiary artesian water-bearing area of Western New South Wales, from the South Australian border to well beyond this side of the River Darling. This was entrusted to Mr. Anderson and carried on till 1891 (it was during this year we had the misfortune to lose our chief and friend Mr. C. S. Wilkinson). In 1890 he examined and reported on the Pambula and Cargo Goldfields; 1892 and 1893 were spent by Mr. Anderson in the survey of the Shoalhaven Valley, accompanied by Mr. P. T. Hammond as Field Assistant, but in June of the latter year he retired from the service and returned to Scotland.

Mr. Anderson's Official Reports are too numerous to mention in detail, but supplementary to these he contributed interesting articles to the Records of the Geological Survey of New South Wales. Prominent amongst these are: "Petrographical Notes on the Eruptive Rocks connected with the Silver-bearing Lodes at Sunny Corner," etc., "The Shell-heaps or Kitchen Middens" of our south-east coast; and in particular "The Occurrence of Opal in New South Wales".

No great lapse of time intervened between the termination of Anderson's Australian work and his appointment to the Geological Survey of India as Mining Specialist, but of this portion of his life I regret I am in possession of very few facts. He resigned his position in October, 1896.

We next hear of Mr. Anderson as Government Geologist of Natal, where he entered on his duties in January, 1899. It was not until the middle of 1901 that his first report on Natal and Zululand appeared. Between these dates the Lower Tugela District mapping was carried out, and a geological reconnaissance of the eastern half of Zululand. Two other very useful items are contained in this report, "Historical Sketch of Natal Geology" and "Bibliography of Natal and Zululand Geology, Part I". There is also a short paper by the writer: on "Fossil Plants from the St. Lucia Coalfield".

In June, 1900, Mr. Anderson acted as one of the examiners in Mineralogy and Geology at the Cape Town University.

His second report appeared in 1904 with a continuation of the Geology of Zululand and a "Report on the Stormberg Coal-measures to the West of Molteno" with Palæontological Reports by Messrs. Seward and Etheridge.

The third and final report appeared in 1907, embracing work accomplished 1903–5. Of this period upwards of seven months (1903–4) were spent in Europe on literary work. In the early part of 1903 he was a member of the Building Stones Commission, instituted by Lord Milner to investigate the distribution and quality of building stones of South Africa. This last report contains an important article on the "Cretaceous Rocks of Natal and Zululand"; another, the discovery in the latter territory of "Marine Fossiliferous Rocks of Tertiary Age containing Mammalian Remains"; and lastly the "Geology of the Drakensberg Mountains". A large portion of the volume is taken up with palæontological articles by Drs. R. Broom and A. S. Woodward, Professor W. B. Scott, Mr. G. E. Crick, and the writer. It is important to note the date of publication of this final report, as Mr. Anderson had already left the Natal Service, resigning his appointment in September, 1905.

After a brief interval he joined the well-known and wealthy firm of Eckstein & Co., mine-owners and financiers of Johannesburg, as mining adviser. In this capacity Anderson continued until some time in 1913, when from failing health he was advised to leave South Africa, and accordingly returned to his home in Edinburgh. During the period of his connexion with this firm there appeared his "Notes on the General Geology of the Waterberg District", etc., read before the Geological Society of South Africa in 1910, and previous to this a joint communication by Professor G. H. Stanley and himself on "The Intimate Relations between Archæology and Geology in South Africa", etc., was read before the same Society in 1909. The Edinburgh climate proved too severe after his long residence abroad, and acting on further advice he visited New South Wales, his first love, and took up his residence in Sydney, June, 1913. Mr. Anderson occupied his time in making occasional short geological excursions to the other States, one in particular to King Island, Bass' Strait. Here he investigated the sand-rock containing extinct marsupial remains. The result of his observations appeared in the Records of the Australian Museum, 1914.

At the beginning of the present year it became evident to his friends here that his health was rapidly declining, and after a very brief final illness he passed away on May 30 from cerebral hæmorrhage in his 56th year.

Mr. Anderson was a minute and accurate observer, a pertinacious man, of reserved demeanour except to a few of his most intimate acquaintances. To them he was of a genial disposition, possessed of a fund of quiet dry humour, and was a staunch and generous friend.

R. Etheridge, jun.

Sydney, New South Wales.
August, 1915.